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# METROPOLITAN WATER AND SEWERAGE BOARD

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FIFTH ANNUAL REPORT

JANUARY 1, 1906

No 6 457.33

5<sup>th</sup>  
1906



MASS. METROPOLITAN WATER & SEWERAGE BOARD  
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COMPLIMENTS OF . . .

**METROPOLITAN WATER AND SEWERAGE BOARD.**

HENRY H. SPRAGUE, CHAIRMAN.

HENRY P. WALCOTT.

JAMES A. BAILEY, JR.

1 ASHBURTON PLACE,

BOSTON.

WILLIAM N. DAVENPORT, Secretary.



GENERAL VIEW OF WACHUSETT DAM, WASTE WEIR, RAILROAD BRIDGE AND LOWER END OF WACHUSETT RESERVOIR.



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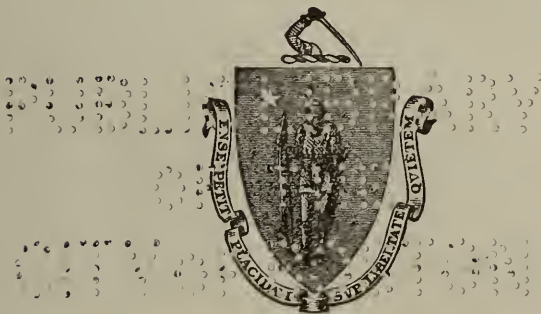
# FIFTH ANNUAL REPORT

OF THE

# METROPOLITAN WATER AND SEWERAGE BOARD.

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JANUARY 1, 1906.



BOSTON:

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Metropolitan Water and Sewerage Board.  
June 20, 1906.

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# METROPOLITAN WATER AND SEWERAGE BOARD.

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*To the Honorable the Senate and House of Representatives of the Commonwealth of Massachusetts in General Court assembled.*

The Metropolitan Water and Sewerage Board, established under the provisions of chapter 168 of the Acts of the year 1901, has already presented to your Honorable Body an abstract of the account of its doings, receipts, expenditures, disbursements, assets and liabilities for the calendar year ending December 31, 1905, and now presents a detailed statement of the operations for the year, being its

## FIFTH ANNUAL REPORT

made since the consolidation of the Metropolitan Water Board and the Board of Metropolitan Sewerage Commissioners on March 20, 1901.

### I. ORGANIZATION AND ADMINISTRATION.

#### (1) BOARD, OFFICERS AND EMPLOYÉS.

The term of office of Henry P. Walcott, M.D., expired on March 21, 1905, and he was reappointed for the three years next succeeding. The membership of the Board has consequently remained as in the preceding year: Henry H. Sprague, chairman, Henry P. Walcott, M.D., and James A. Bailey, Jr. William N. Davenport has continued as secretary, and the auditing department has been placed under his general supervision. Alfred F. Bridgman, who formerly acted as auditor, has been made the purchasing agent, and will also act in the future as paymaster.

A further reduction has been made during the year in the administrative office force. This force now comprises: a book-keeper, an assistant book-keeper, an assistant in auditing, one general clerk, two stenographers, a telephone operator, one messenger, and a janitor with two assistants, one of whom acts as watchman.

George D. Bigelow has been in charge of the conveyancing work, and he has been assisted by Miss Alline E. Marcy, title examiner, and by one stenographer. Miss Celia M. Tibbetts has performed the conveyancing work which has been required in the county of Worcester as her services have been needed.

Frederic P. Stearns has continued as Chief Engineer of the Board, with special charge of the Water Works. Joseph P. Davis and Hiram F. Mills are retained to act as consulting engineers if matters arise requiring their consideration.

The various departments of the Water Works have been, subject to the Chief Engineer, in charge of the following: Dexter Brackett, Engineer of the Sudbury and Distribution departments; Thomas F. Richardson, Engineer of the Dam and Reservoir Department; Frank T. Daniels, Principal Office Assistant, until December 23, when he resigned, and the position was abolished.

The engineering force employed in construction on the Water Works has been greatly reduced. This force, both in construction and maintenance, has, upon the average during the year, comprised, in addition to the persons above named, 6 division engineers, 12 assistant engineers, and others in various engineering capacities and as sanitary inspectors, clerks, stenographers and messengers, to the number of 62, numbering in all, 80. The maximum engineering force employed at any one time during the year on both construction and maintenance was 99.

There have also been employed inspectors, other than engineering inspectors, to the maximum number of 5. Day-labor forces, under the general supervision of the engineers and the immediate direction of foremen, varying in numbers from time to time, have been employed in pipe laying, in general improvements and repairs, and in minor operations.

In addition, a maintenance force, numbering, upon the average during the year, 208, has been required at the pumping stations and upon the reservoirs, aqueducts, pipe lines and other works. This force at the end of the year numbered 173, and was divided as follows: Sudbury and Distribution departments, 165; Dam and Reservoir Department, 8.

The maximum number of men employed upon construction contracts by the various contractors upon the Water Works during the

year was for the week ending June 17, when the number amounted to 669.

William M. Brown, Engineer of the Sewerage Works, has been in charge of both construction and maintenance upon these works.

He was assisted during the year by 2 division engineers who were in charge of both construction and maintenance, 1 division engineer in charge of drafting room and records, 4 assistant engineers, and 4 others, who were employed in various engineering capacities, and a clerk and stenographer. The maximum engineering force employed at any one time during the year on construction and maintenance of the Sewerage Works was 13.

Day-labor forces, under the general supervision of the engineers and the immediate direction of foremen, have been employed on the High-level Sewer in building roads and grading at Nut Island and vicinity, and on the pumping station lot at Ward Street.

The maximum number of men employed upon contracts and upon day-labor construction upon the Sewerage Works during the year was for the week ending July 5, when the number amounted to 60.

The regular maintenance force required for the operation of the pumping stations, the care and inspection of the sewers, and for other parts of the Sewerage Works, exclusive of engineers and day-labor construction forces before enumerated, has upon the average numbered 118.

The whole force of the Sewerage Department at the end of the year numbered 130, of whom the engineer in charge and 11 assistants and draftsmen were engaged in general upon the works, and, of the remainder, 74 were employed upon the North System and 44 upon the South System.

## (2) OFFICES AND BUILDINGS.

The office of the Metropolitan Water and Sewerage Board is in the buildings numbered 1 and 3 Ashburton Place, at the corner of Somerset Street, in which are also located the secretary's, auditing and conveyancing offices, and the main engineering offices of both the Water Works and the Sewerage Works.

The headquarters of the Wachusett Dam and Reservoir Department of the Water Works have been maintained in the office building in Clinton. Branch offices of the Dam and Reservoir Department



were maintained, one in West Boylston and one in Oakdale, until November 21, and one at the Wachusett Dam until November 28. Headquarters of the Sudbury and Distribution departments have been maintained in the central office in Boston. For the Sudbury Department a branch office has been maintained at South Framingham. Branch headquarters of the maintenance force of the Water Works in the northern part of the District have been in buildings in the Glenwood pipe yard in Medford, where there are offices, shops, store rooms and stables; and the maintenance force for the southern part of the District has headquarters in buildings at the Chestnut Hill Reservoir.

Branch headquarters of the maintenance and repair forces of the Sewerage Works are maintained at the East Boston and Ward Street pumping stations and at the stock yard at Hough's Neck.

### (3) CONVEYANCING.

The various settlements effected by the Board involved the examination by the conveyancers of 47 titles in water cases, and 9 titles in sewer cases, a total of 56. In 35 of the cases deeds were drafted and executed. In the other cases judgments were obtained by agreement or after trial.

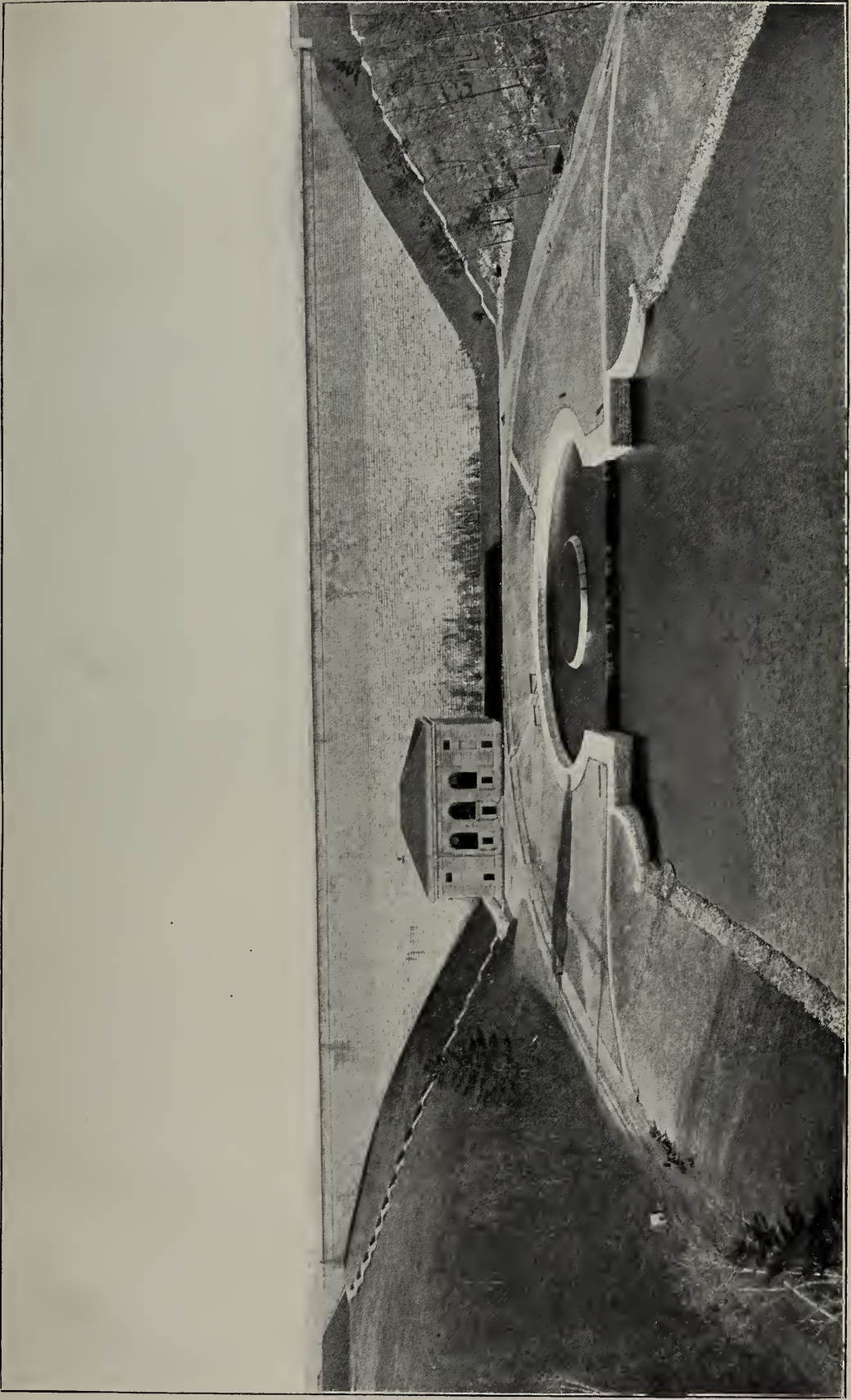
One instrument of discontinuance of roads was drafted and executed, being for a part of Holbrook Street in West Boylston, and 2 determinations have been drafted affecting highways in West Boylston.

The Spot Pond hearings in the earlier part of the year required a large amount of work from the conveyancers, and much other work has been done at the request of the Attorney-General and his assistants in the preparation of cases for trial and hearing.

By reason of the expiration, on July 1, 1905, of the time within which could be brought suits for damages in connection with water works, other than damages for real estate taken, a large number of new suits have been entered in court; and for these suits examinations of titles of the lands involved are, to a greater or less degree, required, this being necessary whether the suits are settled by the Board or tried in court. A considerable portion of this work has been accomplished.

The conveyancers were called upon to draft many other instruments than those above enumerated, and to make various investigations relative to other real estate in charge of the Board.





WACHUSETT DAM AND POWER AND GATE HOUSE—AT THE END OF 1905.



During the year all the deeds remaining uncopied, relating to the Water Works, have been copied, as well as a considerable portion of the deeds relating to the Sewerage Works.

A card index has also been in progress and is nearly finished, showing the names of the owners whose property has been affected by the operations of the Board, and memoranda as to the date, amount, area, and purpose of takings and deeds, with reference to abstracts of titles and copies of deeds.

## II. METROPOLITAN WATER DISTRICT.

The Metropolitan Water District as now constituted comprises the cities of Boston, Chelsea, Everett, Malden, Medford, Melrose, Newton, Quincy and Somerville, and the towns of Arlington, Belmont, Hyde Park, Lexington, Milton, Nahant, Revere, Stoneham, Watertown and Winthrop, in all, 19 municipalities. The District has an area of 171.7 square miles. The population of the District above comprised, as of July 1, 1905, the date upon which calculations for the Water Works are based, is estimated at 953,580.

## III. WATER WORKS — CONSTRUCTION.

The amount expended for construction, including real estate acquired and payment of claims on account of the Water Works, during the year 1905, was \$655,958.47. Of this amount, \$524,990.68 was expended on account of the Wachusett Dam and Reservoir; \$58,087.49 on account of the Weston Aqueduct and Reservoir; \$7,164.86 for the improvement of the Wachusett watershed; \$36,711.68 for the acquisition of existing water works; \$10,798.03 for construction in the Distribution Department; and the remainder, \$18,205.73, for various other operations on the works. The total amount expended for construction since the beginning of the Water Works in the year 1895 has been \$39,044,214.23.

### (1) WACHUSETT DAM AND RESERVOIR.

#### (a) *Wachusett Dam.*

The masonry of the Wachusett Dam was substantially completed during the past year, there only remaining to be laid the granolithic surface which is to form the finish of the top of the dam. The cornice stones of the dam reached the height of 415 feet above the Boston City Base, and the lowest point in the dam, which is in



the cut-off trench, is 186.8 feet above the City Base. The maximum height of the structure, therefore, is 228.2 feet. The length of the main dam, including the terminal structures, is 971 feet, and the length of the waste-weir beyond the bastion at the northwesterly end is 452 feet. The total length of the dam, including the corewall, is 1,476 feet. The stone masonry has amounted to 263,412 cubic yards, the brick and concrete masonry to 10,761 cubic yards, and there have been used in the work 81,103 barrels of Portland cement and 182,480 barrels of natural cement.

The upper gate-chamber, which is built within the structure of the dam, and the chamber in the bastion at the northwesterly end of the dam, have been completed. There still remain to be built the brass fences, which for protection are to surmount the dam on both the up-stream and down-stream sides.

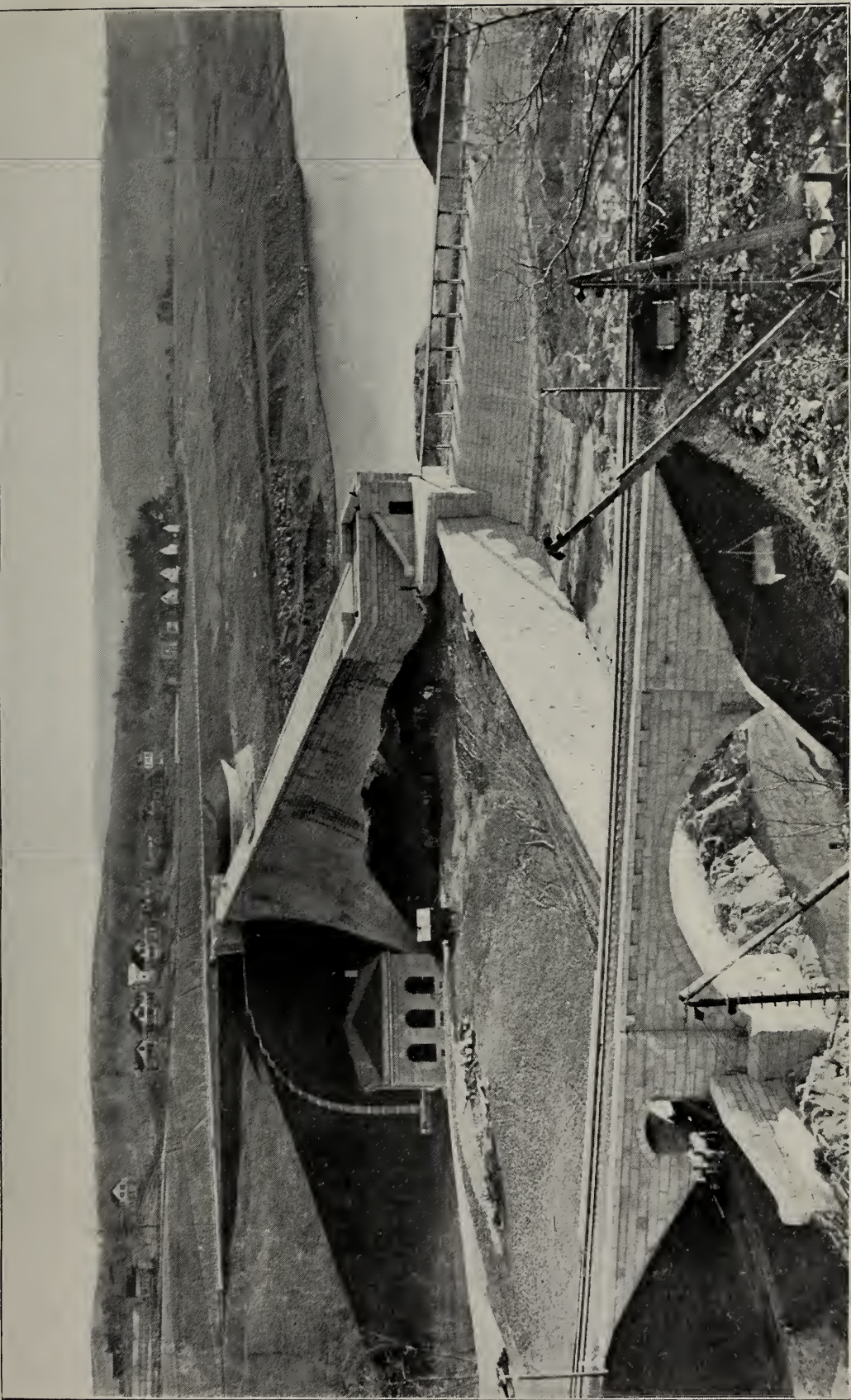
The waste-weir, which runs northwesterly at an angle from the bastion in the main dam, and which provides for an overflow in case of necessity, has been completed. Standards have been placed upon the weir to secure the flash-boards which are provided in order to prevent a waste of water from waves passing over the crest of the weir. A walk is also provided over the waste-weir, as well as a track for a car to be used in transporting the flash-boards to and from the storage room in the bastion.

The work of completing the arch bridge, which forms a part of the permanent location of the Central Massachusetts Railroad, has been carried on during the year, and, upon the removal of the cableway towers, the railroad embankment for the permanent track was completed. The arch bridge crosses the waste channel about 225 feet below the waste-weir. The bridge has a length of about 170 feet, with a span of 58 feet over the waste channel. East of the main span is a smaller arched opening, through which passes the road to be built upon this side of the river from the valley to the bastion.

By the removal of the cableways and the change of the railroad to its permanent location, the opportunity was afforded to complete the excavation of the waste channel; and at the end of the year nearly all of the excavation necessary had been made.

Much grading has been done on both the hillsides below the dam, and while many of the trees and shrubbery have been left, the ground has been covered with soil. Successive flights of granite steps have been built from each end of the dam to the bottom of the





VIEW OF WACHUSETT DAM AND RAILROAD OVER WASTE CHANNEL.





valley, with granolithic walks of varying lengths between. The road from the bottom of the valley to the bastion on the northwesterly side has been partially constructed. A considerable amount of soil remains in the spoil banks at the northwesterly end of the dam, which is to be used during the coming season for covering the slopes of the permanent railroad embankment and for other purposes.

(b) *Wachusett Reservoir.*

The removal of soil from the bed of the reservoir, which remained to be accomplished, was confined to the extreme upper end of the reservoir, with the exception of a small area near the South Dike, the soil of which had been reserved for use at the Wachusett Dam. The principal portion of the work in the reservoir during the past year consisted of excavating the material from the Stillwater River above the location of the Worcester, Nashua and Portland Division of the Boston & Maine Railroad and of enlarging and changing the channel of the Quinepoxet River, of the building of a concrete dam at the upper end of the channel in order to prevent the wearing away of the river bed above the location of the dam and also to prevent the filling of the upper end of the reservoir with the sand and gravel which would be washed down the channel. In all the work of the year about 276,554 cubic yards of earth and soil were removed. This material was deposited upon the railroad and highway embankments, and was also taken for covering deep beds of muck, which it was not desirable to excavate, and for shallow flowage embankments.

Since the beginning of the work 3,941 acres have been stripped for the purposes of the reservoir, and there have been removed 6,912,052 cubic yards of soil. Of the total amount of soil removed, 4,955,936 cubic yards have been deposited in the North Dike; 160,895 cubic yards have been deposited in the South Dike; 1,149,917 cubic yards have been used for filling shallow flowage areas; 603,002 cubic yards have been deposited in highway and railroad embankments; and 42,302 cubic yards have been used for grading grounds near the dam and for miscellaneous purposes.

During the year riprap to the extent of 11,991 cubic yards was placed upon the water face of the South Dike, where the dike will be particularly exposed to the action of heavy waves. The stone used was obtained from the waste piles of the quarry from which

the stone for the dam was quarried. A gap in the dike through which the quarry railroad passed was also filled with material which was removed from the embankments of the quarry railroad.

Ditches with sides paved and board bottoms have been constructed in order to drain the swampy ground below the South Dike and the pit from which the sand was obtained for the construction of the masonry of the Wachusett Dam. A ditch has also been dug to drain the swampy land near the Lamson nursery upon the northerly side of the reservoir.

The number of buildings in West Boylston removed from the reservoir site during the year was 44, which embraced 36 houses, 6 barns, a store and a police station. The number of buildings removed prior to the year was 271, making the total number in West Boylston removed to the present time 315. The number of buildings removed from the site of the reservoir since the beginning of the work has been: in Boylston 108, in Clinton 38, in Sterling 7, making a total removal, including West Boylston, of 468 buildings.

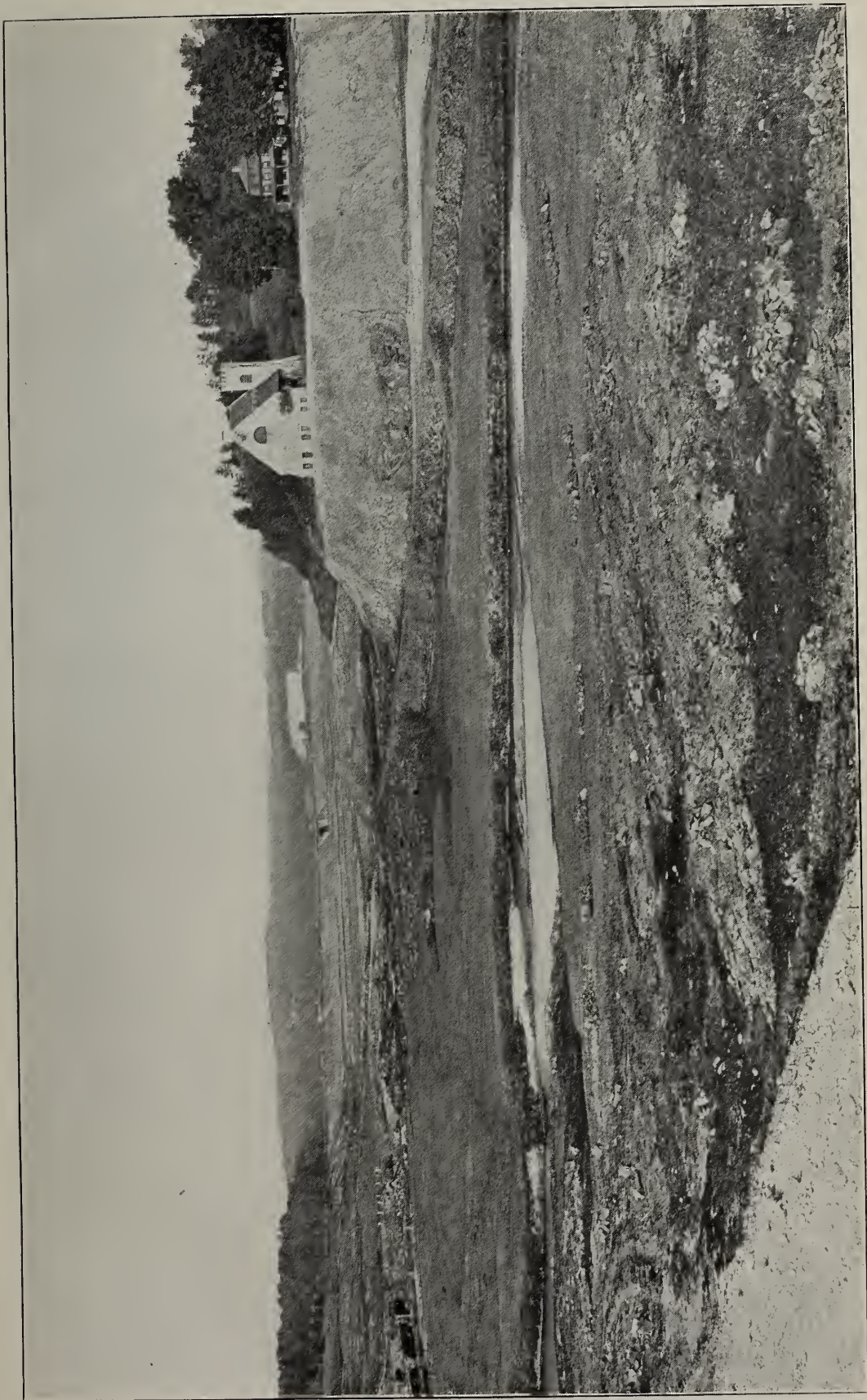
Considerable work was performed during the season in obtaining elevations of the bottom of the reservoir after excavation had been completed, and already 3,420 acres out of a total of about 3,950 acres have been covered by these final records. From the record sheets tables are prepared to show the capacity of the reservoir at each tenth of a foot up to elevation 370. Surveys of the marginal line of the watershed have also been in progress during the year, and this line has now been surveyed a distance of 38.5 miles, the total length of the line around the margin of the watershed being about 69 miles.

(c) *Forestry.*

The two nurseries, one upon the north side and the other upon the south side of the reservoir, have been maintained. There have been transplanted from the beds to rows in the nurseries more than 150,000 seedlings. The nurseries now contain some 740,000 seedlings and plants, of which by far the larger number are white pines and arbor vitæ, but there are many Scotch pines, white, Douglas and Norway spruces, maples, oaks, locusts and birches, besides walnuts, ashes, hemlocks, larches and tamaracks.

There are about 3,348 acres of land about the reservoir belonging to the Commonwealth above the flow line, excluding the more remote land along the Quinepoxet River. On this land there were





BED OF WACHUSETT RESERVOIR NEAR BAPTIST CHURCH IN WEST BOYLSTON.



about 1,431 acres already covered with wood. It has been the purpose to cut out fruit trees as well as mature and undesirable trees, and where needed to plant new growth taken principally from the nurseries. Areas amounting to about 250 acres were thus planted during the year. There have already been planted in all about 937 acres, and there remains an area of about 483 acres which it is proposed to plant in the future. Besides about 197 acres of marginal land lying immediately adjacent to the shores of the reservoir, there are about 300 acres of land which will probably remain open and unplanted with trees.

Seedlings, principally of white pine, have been planted along both sides of the public roads within the lands of the Commonwealth, and arbor vitæ and white pine seedlings have also been planted on the outside line of the immediate marginal lands of the reservoir.

The marginal line of the reservoir is 38.2 miles long, and there remain about 5.5 miles of the line of the marginal strip to plant with trees, there being a distance of about 5.7 miles along dikes, highways and railroads, which, as proposed, is not to be planted.

*(d) Location, Construction and Discontinuance of Roads.*

A highway has been constructed during the past year along the southwesterly side of the reservoir between Oakdale and West Boylston, the portion extending for a distance of about 2,930 feet being a new highway, and the remaining portion for about 2,110 feet to Central Street in West Boylston consisting of the improvement of the existing highway known as Crescent Street.

The new highway which was built during the preceding year from the southerly end of the bridge over the Quinepoxet River and through the village of Oakdale, along the northerly side of the reservoir to the junction of Sterling and Lancaster streets, and the new highway which crosses the reservoir in West Boylston in continuation of Worcester Street, have both been surfaced with broken stone.

A small portion of Boylston Street in the town of Boylston near the South Dike has also been surfaced with stone. Considerable work has been done by the day-labor forces on other highways, in the grading and seeding of highway slopes, building of fences and railings, and widening of culverts.



A location has been determined for an extension of the highway in Oakdale from a point near Wheeler Street, southerly across the railroad, Holden Street and Quinepoxet River, and also across a portion of Newton Street discontinued to the part of Newton Street still existing in the town of West Boylston.

A new location also has been determined of the street extending from the above-described highway across Newton Street discontinued westerly to Holden Street, taking the place of the portion of Holden Street, extending westerly from the highway for about 1,912 feet.

A slight change was made in the location of the new highway in West Boylston laid out from Worcester Street to Lancaster Street, changing the location of the centre line.

The following are lists of the roads relocated and discontinued during the year : —

*Location of Roads in the Year 1905.*

No.	LOCATION.	Description.	Date of Acceptance.
13	West Boylston, Oakdale Village.	A highway connecting the two new highways laid out in determination No. 12, extending southerly from the end of the first of said highways in Oakdale from a point 125 feet westerly from Wheeler Street, crossing the railroad, the Quinepoxet River and Newton Street discontinued, to the northerly end of the second highway at a point in Newton Street discontinued.	April 4, 1905.
14	West Boylston.	A highway extending westerly from the above connecting highway, near where it crosses the river, to Holden Street. Amendment in the location of the new highway laid out in determination No. 8, from Worcester Street to Lancaster Street, narrowing the width of the finished portion of the roadway and changing the location of the centre line.	April 18, 1905.

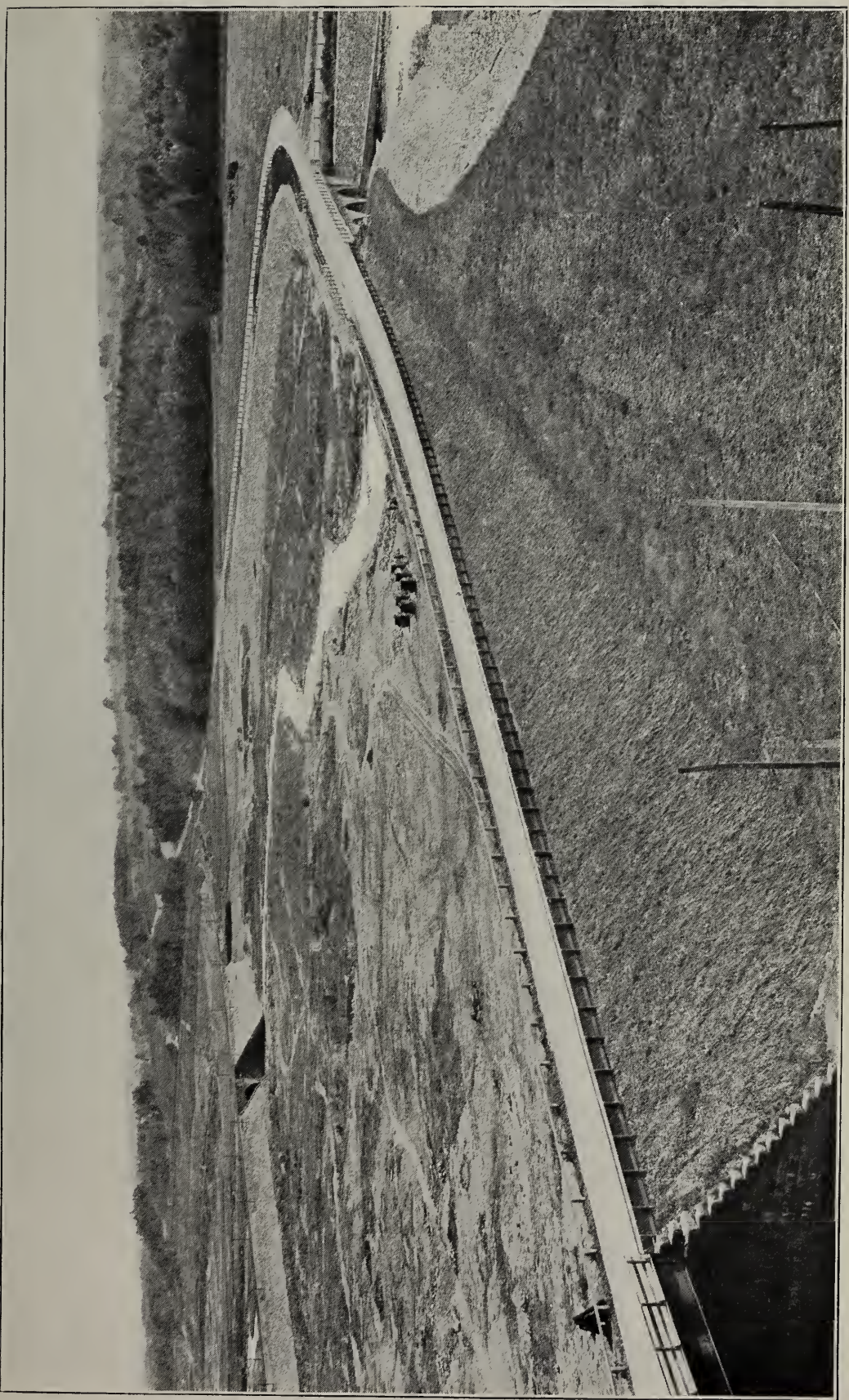
*Discontinuance of Roads in the Year 1905.*

No.	LOCATION.	Description.	Date of Discontinuance.
26	West Boylston, Oakdale Village.	That part of Holden Street extending from a point near the new highway between Oakdale and West Boylston near Harris Street, about 1,600 feet to the new highway extending westerly from the first-named highway to Holden Street.	April 26, 1905.

*(e) Relocation of Central Massachusetts Railroad.*

The travelling cableways which had been used for the construction of the Wachusett Dam having been removed, the permanent road-bed of the Central Massachusetts Railroad at this point has been





RELOCATION OF NEWTON STREET AND QUINEPOXET RIVER BRIDGE AT UPPER END OF WACHUSETT RESERVOIR.





built to take the place of the temporary location first provided. This work required the building not only of the necessary railroad embankments but the arch bridge over the waste channel. Some further work will be necessary upon the slopes of the embankments. The new location has been used for the passage of trains since October 23. The entire length of the new location is about 1,215 feet.

(f) *Clinton Catholic Cemetery.*

No action has been taken by either the Roman Catholic Bishop of Springfield or the St. John's Catholic Cemetery Association at Clinton, toward effecting a final settlement under the tripartite agreement which was executed by them and the Board on account of the taking of the lands of the old cemetery in Clinton for the Wachusett Reservoir, and the acquisition of new cemetery lands in Lancaster to take the place of the old grounds.

The title to the larger part of the lands in Lancaster now devoted to cemetery purposes is held by the Commonwealth, and there is a considerable sum of money payable to the Cemetery Association upon the release to the Commonwealth of the old cemetery lot and of all claims for damages, which is awaiting an agreement between the two other parties.

(2) IMPROVEMENT OF SPOT POND BROOK.

The city of Melrose, prior to the last report, had brought a petition for the appointment of commissioners under chapter 406 of the Acts of the year 1904, being "An Act to provide for the improvement of Spot Pond Brook by the Metropolitan Water and Sewerage Board." No hearing, however, has been called for under the petition, and consequently no further action has been taken under the act.

(3) POLICE PROTECTION.

Owing to the reduction of the areas upon which the work of construction has been carried on, the Board has been enabled to make a great reduction in the number of officers appointed for police protection.

On January 1, 1905, the officers employed were: in Clinton 3, in Boylston 1, in West Boylston 5. On June 5, 2 additional officers were appointed in Clinton, but on November 20 the services

of all the police officers employed by the towns at the expense of the Board were dispensed with, with the exception of those in Clinton, where 2 are still retained in service.

#### (4) ACQUISITION OF LANDS AND LAND SETTLEMENTS.

The Board acquired by purchase during the year 122.79 acres, of which 67.04 acres were in Holden and 55.75 acres in Sterling. No takings of land were made during the year.

Settlement has been effected with the owners of all the lands acquired, either by purchase or by taking, by the Board for the Metropolitan Water Works since the beginning of operations, except for 106.477 acres, not including the takings of Spot Pond and the contiguous lands of the cities of Malden, Medford and Melrose, settlement for which is still pending. Payments on account, however, have been made to these cities, amounting to \$342,820.68.

Settlements under purchases and takings of land, for all purposes of the Water Works, have been effected in the past year in 25 cases, and for an aggregate of 142.756 acres with the buildings thereon. Of these cases 9 were on account of the Wachusett Reservoir, 9 on account of the Weston Aqueduct, 4 on account of takings for a low-service pipe line in Medford, 2 for the improvement of the Wachusett watershed, and 1 on account of the improvement of the Sudbury watershed. The sums paid in all these settlements have amounted to \$47,508.77. In 3 of these cases the settlements have been results of suits at law, and the total amount paid in the court settlements has been \$2,277.06.

Under chapter 317 of the Acts of the year 1904, providing, in cases of takings under the right of eminent domain, for partial payments in advance of the judgment of a judicial tribunal, sums on account have been paid, amounting to \$5,416.58. There were 6 of these cases, affecting 14.01 acres.

On January 1, 1906, there was pending final action in 12 settlements which had been supposed to be effected, 2 of which had been made in 1901, 2 in 1903, 2 in 1904 and 6 in 1905.

Inasmuch as on July 1, 1905, the time expired within which could be brought petitions for the determination of damages for the taking of water rights, where no land was taken in connection with such water rights, and for the determination of all other damages provided for on account of the operations of the Board, except damages for real estate taken, new cases, to the number of 136, were brought



shortly previous to that date. Of these cases, 3 were for damages to mill property; 6 were for the widening of Crescent Street in West Boylston; 19 for damages to the intervale or meadow land on the Nashua River in Clinton, Bolton, Lancaster and Harvard; 19 for damages to land by flooding in Germantown in Clinton; 10 for damages for discontinuance of roads in Clinton; 21 for depreciation and other damages in Boylston; 4 for like damages in Sterling; 19 for damages for depreciation in West Boylston; 1 for blasting; 2 for claims on account of the Worcester County Truant School; and 1 the nature of which is not evident.

Since the beginning of operations upon the Metropolitan Water Works, the number of settlements effected on account of the acquisition of land for the purposes of the Water Works, including the works of water supply acquired from the city of Boston on January 1, 1898, has amounted to 851; and under them the Board has acquired rights, in fee or of easements, in 15,953.35 acres, or 24.927 square miles, for which an aggregate of \$16,921,753.86 has been paid. Only 44 of these cases have been settled by judgments of court, and the total amount paid under these judgments has been \$139,207.29 or a little less than 1 per cent. of the whole amount paid.

These purchases and takings for which the settlements have been made include lands taken in fee with the buildings thereon and the water and other rights connected therewith, and lands in which easements and other rights are taken; but they do not include settlements for diversion of water, depreciation and other damages connected with lands not acquired, and in which no fee or easement has been taken.

Summary of Land Settlements for Water Works to December 31, 1905.

LOCATION.	FOR THE YEAR 1905.			FROM BEGINNING OF WORK.		
	Area in Acres.	Number of Settlements.	Payments.	Area in Acres.	Number of Settlements.	Payments.
<i>Wachusett Reservoir.</i>						
Berlin, . . . . .	-	9	\$6,015 00	16.700	429	\$2,949,437 10
Boylston, . . . . .	-			4,003.116		
Clinton, . . . . .	1.080			1,274.763		
Holden, . . . . .	-			167.000		
Sterling, . . . . .	55.750			770.237		
West Boylston, . . . . .	.729			1,652.850		
Total, . . . . .	57.559	9	\$6,015 00	7,884.666	429	\$2,949,437 10

*Summary of Land Settlements for Water Works, etc. — Continued.*

LOCATION.	FOR THE YEAR 1905.			FROM BEGINNING OF WORK.		
	Area in Acres.	Number of Settlements.	Payments.	Area in Acres.	Number of Settlements.	Payments.
<i>Improving Wachusett Watershed.</i>						
Holden, . . . . .	67.040	} 2	\$22,960 00 <sup>1</sup>	151.340	} 5	\$60,960 00
West Boylston, . . . .	-			64.430		
Total, . . . . .	67.040	2	\$22,960 00	215.770	5	\$60,960 00
<i>Wachusett Aqueduct.</i>						
Berlin, . . . . .	-	} -	-	47.815	} 68	\$74,362 40
Clinton, . . . . .	-			12.310		
Marlborough, . . . . .	-	} -	-	51.530		
Northborough, . . . .	-			89.000		
Southborough, . . . .	-	} -	-	100.060		
Total, . . . . .	-	-	-	300.715	68	\$74,362 40
<i>Sudbury Reservoir.<sup>2</sup></i>						
Marlborough, . . . . .	-	} -	-	751.980	} 153	\$658,318 75
Southborough, . . . .	-			2,019.080		
Total, . . . . .	-	-	-	2,771.060	153	\$658,318 75
<i>Improving Sudbury Watershed.</i>						
Ashland, . . . . .	-	} 1	-	.630	} 39	\$16,522 16
Marlborough, . . . . .	-			.800		
Northborough, . . . .	-	} 1	-	178.049		
Southborough, . . . .	-			4.826		
Westborough, . . . . .	-	} 1	-	205.487		
Total, . . . . .	-	1	-	389.792	39	\$16,522 16
<i>Clinton Sewerage System.</i>						
Clinton, . . . . .	-	} -	-	5.315	} 36	\$37,794 40
Lancaster, . . . . .	-			129.835		
Total, . . . . .	-	-	-	135.150	36	\$37,794 40
<i>Weston Aqueduct.</i>						
Framingham, . . . . .	1.240	} 9	\$15,037 00	102.125	} 85	\$181,893 40
Newton, . . . . .	.987			1.308		
Southborough, . . . .	-	} 9	\$15,037 00	.450		
Wayland, . . . . .	3.860			73.299		
Weston, . . . . .	11.253	} 9	\$15,037 00	295.195		
Total, . . . . .	17.340	9	\$15,037 00	472.377	85	\$181,893 40

<sup>1</sup> \$60,000 due on one settlement.<sup>2</sup> Including settlements made by city of Boston.

*Summary of Land Settlements for Water Works, etc. — Concluded.*

LOCATION.	FOR THE YEAR 1905.			FROM BEGINNING OF WORK.		
	Area in Acres.	Number of Settlements.	Payments.	Area in Acres.	Number of Settlements.	Payments.
<i>Distribution System.</i>						
Arlington, . . . . .	-	4	\$3,496 77	1.896	34	\$171,916 85
Boston, . . . . .	-			1.359		
Brookline, . . . . .	-			.051		
Malden, . . . . .	-			.158		
Medford, . . . . .	.817			3.213		
Newton, . . . . .	-			5.147		
Quincy, . . . . .	-			5.224		
Revere, . . . . .	-			.404		
Somerville, . . . . .	-			.009		
Stoneham, . . . . .	-			19.409		
Total, . . . . .	.817	4	\$3,496 77	36.870	34	\$171,916 85
<i>Improving Lake Cochituate.</i>						
Natick, . . . . .	-	-	-	2.950	1	\$1,600 00
Total, . . . . .	-	-	-	2.950	1	\$1,600 00
<i>Boston Water Works<sup>1</sup> (taking of Jan. 1, 1898).</i>						
Arlington, . . . . .	-	-	-	1.586	1	\$12,768,948 80 <sup>2</sup>
Ashland, . . . . .	-			652.124		
Boston, . . . . .	-			160.630		
Framingham, . . . . .	-			663.460		
Hopkinton, . . . . .	-			654.729		
Marlborough, . . . . .	-			30.552		
Medford, . . . . .	-			25.140		
Natick, . . . . .	-			436.223		
Needham, . . . . .	-			31.695		
Newton, . . . . .	-			78.308		
Sherborn, . . . . .	-			40.385		
Somerville, . . . . .	-			12.426		
Southborough, . . . . .	-			17.168		
Wayland, . . . . .	-			177.875		
Wellesley, . . . . .	-			139.115		
Westborough, . . . . .	-			545.912		
Winchester, . . . . .	-			76.094		
Woburn, . . . . .	-			.578		
Total, . . . . .	-	-	-	3,744.000	1	\$12,768,948 80
Aggregates, . . . . .	142.756	25	\$47,508 77	15,953.350	851	\$16,921,753 86

<sup>1</sup> Estimated areas.<sup>2</sup> Includes interest.



The settlements above enumerated include all lands acquired for which a complete settlement has been made. About 113.388 acres of the lands acquired and settled for have subsequently been sold and conveyed by the Board.

The tables of settlements for lands acquired do not include : —

1. Lands for which "payments on account" under chapter 317 of the Acts of the year 1904 have been made, there being 14.01 acres on account of which \$5,416.58 has been paid.

2. Spot Pond and adjacent lands in Malden, Medford and Melrose, comprising about 271.177 acres, exclusive of the area of land under Spot Pond which is not estimated, on account of which \$342,820.68 has been paid.

3. Lands acquired but not paid or settled for, amounting to about 163.309 acres, including 50.765 acres previously owned by the Commonwealth, and 66.761 acres of other lands for which no claims will probably be made.

4. Lands embraced in the St. John's Catholic Cemetery, comprising 26.39 acres in Clinton and 69.75 acres in Lancaster.

5. Street areas.

The total area of land in which the Commonwealth has acquired for the Metropolitan Water Works either the fee, easements or other rights is about 16,575.422 acres, or about 26 square miles.

#### (5) CLAIMS AND SETTLEMENTS FOR LOSS OF BUSINESS.

For injury to business caused by the carrying out of the Metropolitan Water Act in the towns of Boylston and West Boylston and in portions of the towns of Sterling and Clinton, but one additional claim was filed. Settlements were made during the year in 23 cases. In some of these cases claims had been filed previous to the past year, but in the greater number no statements of claim had ever been filed with the Board, but suits for damages had been directly brought in court. These suits were brought after the decision of the Supreme Judicial Court in the case of *Allen v. the Commonwealth*, which declared that under certain circumstances farming was an established business within the meaning of the Metropolitan Water Act, for which damages could be recovered. Settlements were accordingly effected in several of these suits by the Attorney-General, with the approval of the Board. No claims were disallowed during the year.



The number of claims of this class settled since the beginning of the Water Works has been 305, and the total sum paid on account of such claims has been \$149,897.36. All of these claims except 18 have been settled outside of the court.

(6) CLAIMS AND SETTLEMENTS FOR LOSS OF EMPLOYMENT.

No claims for loss of employment by residents of West Boylston have been filed during the year, and no settlements of cases of this class have been made. There are, however, pending in the courts two cases which the Board refused to allow.

The whole number of settlements for such claims effected since the beginning of the operations of the Board have been 474. The total amount paid on account of these claims has been \$85,884.65. All of these claims have been settled without resort to the courts.

(7) CLAIMS AND SETTLEMENTS FOR DEPRECIATION OF REAL ESTATE.

Settlements for depreciation in the value of real estate not taken by the Board were made on account of lands situated in the towns of West Boylston and Sterling only, all of the Clinton cases having been previously settled. Settlements have been effected in 17 cases of this class during the year ending December 31, 1905, and the sum of \$14,089.72 has been paid. Of these, 2 were settled in the courts.

The total number of claims for depreciation settled up to December 31, 1905, has been 265, and the total amount paid thereunder has been \$258,485.49. All of these claims except 41 were settled out of court.

Many suits for damages have been brought under chapter 436 of the Acts of the year 1904, which provided that the owners of real estate situated in that part of the town of Boylston lying on the southerly and southeasterly sides of the reservoir and within the limits of the Nashua River watershed should have the right to recover for the depreciation in value of real estate not taken but injured by reason of the operations of the Metropolitan Water and Sewerage Board, in a manner similar to that provided for owners of real estate in the town of West Boylston. No settlements have yet been effected, and no trials have been reached in the pending suits.

### (8) CLAIMS ON ACCOUNT OF DIVERSION OF WATER.

There have been no claims filed during the year for damages for the diversion of water. The total sum paid under settlements and judgments for such claims since the beginning of the construction of the Water Works has been \$1,135,708.91.

The sums enumerated as paid in these and in the preceding cases do not include amounts paid for expert services and court expenses.

## IV. WATER WORKS — MAINTENANCE.

The maintenance and operation of the Water Works, with the exception of the Wachusett Reservoir and Aqueduct and the Clinton Sewerage Works, have been in charge of the Engineer of the Sudbury and Distribution departments. He is assisted by Charles E. Haberstroh, who has the immediate supervision of the Sudbury and Cochituate works and of the portion of the Weston Aqueduct above the Weston Reservoir; by George E. Wilde, who has the immediate supervision of the Weston Reservoir and the remainder of the Weston Aqueduct and of all the reservoirs and pipe lines within the Metropolitan District; and by John W. Lynch, who has charge of the several pumping stations. The maintenance of the Wachusett Reservoir and Aqueduct has been in charge of the Engineer of the Dam and Reservoir Department.

### (1) OPERATION OF WORKS.

Maintenance in connection with the Water Works has embraced the care and operation of the Chestnut Hill high-service and low-service pumping stations; the Spot Pond, Arlington and West Roxbury pumping stations; the Clinton sewerage pumping station and filter-beds at Clinton; the Pegan Brook pumping station and filter-beds at Natick; the Mystic pumping station at Medford; the Wachusett Reservoir, Lake Cochituate, the Sudbury Reservoir, and the various smaller storage reservoirs in the Sudbury watershed; the Marlborough filter-beds; Spot Pond, Chestnut Hill Reservoir, and the smaller distributing reservoirs in different portions of the District; the Cochituate, Sudbury, Wachusett and Weston aqueducts; about 84 miles of distributing pipes; as well as the various pipe yards, gate-houses, siphon and terminal chambers and other structures connected with the several reservoirs and aqueducts, dwellings

for attendants, and various other buildings used or held for operating purposes.

All of these works, with the exception of the Mystic pumping station, have been in active operation during the year.

## (2) STORAGE RESERVOIRS.

The reservoirs of the Cochituate and Sudbury watersheds have normal capacities amounting to 15,858,500,000 gallons, though a somewhat larger amount of water is actually held by these reservoirs at the periods of maximum height of the water. These capacities are as follows:—

Cochituate watershed:—		Gallons.
Lake Cochituate, including Dudley Pond,	. . .	2,242,400,000
Sudbury watershed:—		
Sudbury Reservoir,	. . . . .	7,253,500,000
Framingham Reservoir No. 1,	. . . . .	287,500,000
Framingham Reservoir No. 2,	. . . . .	529,900,000
Framingham Reservoir No. 3,	. . . . .	1,183,500,000
Ashland Reservoir,	. . . . .	1,416,400,000
Hopkinton Reservoir,	. . . . .	1,520,900,000
Whitehall Reservoir,	. . . . .	1,256,900,000
Farm Pond,	. . . . .	167,500,000
Total,		15,858,500,000

The new Wachusett Reservoir has a capacity of more than 63,000,000,000 gallons.

The quantity of water stored in all of the storage reservoirs, including the Wachusett Reservoir, on January 1, 1905, was 15,638,100,000 gallons. This quantity was increased by the early rainfalls in January by about 4,000,000,000 gallons. Subsequently the quantity was lessened until the spring rains came. By these rains the quantity was increased to a maximum, on May 1, of 33,708,200,000 gallons. In the following four months there was a loss in storage of about 7,000,000,000 gallons. The early rains of September, however, caused an increase of about 4,000,000,000 gallons, and at the end of the year the quantity stored was 28,971,900,000 gallons, an excess of 13,333,800,000 gallons over the quantity in storage at the end of the preceding year.

The Wachusett Reservoir contained, at the beginning of the year 1905, 4,409,600,000 gallons of water, the water being 33 feet deep



at the dam. The largest quantity of water held in the reservoir was on April 28, when it contained 20,697,900,000 gallons, having a depth at the dam of 65.6 feet. There were 17,115,300,000 gallons in storage at the end of the year. An average of 2,309,000 gallons per day was discharged from the reservoir into the river below the dam, under the requirements of law, for the use of the Lancaster mills and others. Had there been a normal rainfall, especially during the earlier part of the year, when the larger part of water in storage is collected, a much greater quantity would have been stored.

An average of 71,877,000 gallons per day was drawn from the Wachusett Reservoir and conveyed through the Wachusett Aqueduct into the Sudbury Reservoir. The Sudbury Reservoir was kept full or nearly full during the entire year, as well as Framingham Reservoir No. 3. The water in the Sudbury Reservoir in part overflowed or was discharged through pipes into Framingham Reservoir No. 3, which is situated directly below upon the river, and in part was discharged into the Weston Aqueduct. Water was drawn from Framingham Reservoir No. 2 during periods amounting to 10 months; from Ashland Reservoir during 6 months; from Hopkinton Reservoir during 6 months; and from Whitehall Reservoir during a period of about 2 months. During all or parts of 15 days water was drawn from Framingham Reservoir No. 1 and discharged into Lake Cochituate. No water was drawn from Farm Pond for the use of the Metropolitan District during the year.

Lake Cochituate was maintained at a high level during nearly all of the year, the lowest level reached being in November, when the surface of the water was about  $6\frac{1}{2}$  feet below high water. An average of 15,313,000 gallons per day was drawn from the lake during the year. During the month of July 20,800,000 gallons were discharged from Dudley Pond into Lake Cochituate. The water from Dug Pond is received into the lake by an overflow pipe.

It is estimated that the Spot Pond watershed yielded an average of 310,000 gallons per day, which was in addition to the quantity pumped into the pond.

Near the Sudbury Dam a gravel driveway has been built over the northerly end of the dam to the head-house of the Weston Aqueduct, and unsightly places below the dam have been covered with loam. A large number of trees have been set out on the grounds, and slight repairs have been required on the retaining wall of the channel

below the dam. At Lake Cochituate, and also at the Framingham and Ashland reservoirs and at Farm Pond, various repairs have been required on the buildings and gate-houses and in the masonry connected with the dams.

### (3) DISTRIBUTING RESERVOIRS.

The distributing reservoirs, being situated within the Metropolitan District, are maintained both for facilitating the distribution of water and affording protection in cases of emergency. They are usually kept filled, or nearly filled, with water. The Weston Reservoir is included in the list of distributing reservoirs, as it contains a considerable quantity of water which is available for emergencies, although its particular purpose is that of an equalizing reservoir. The capacities of these reservoirs are as follows : —

	Capacity in Gallons.
Spot Pond, . . . . .	1,791,700,000
Chestnut Hill Reservoir, . . . . .	300,000,000
Fells Reservoir, . . . . .	41,400,000
Mystic Reservoir, . . . . .	26,200,000
Waban Hill Reservoir, . . . . .	13,500,000
Forbes Hill Reservoir, . . . . .	5,100,000
Bear Hill Reservoir, . . . . .	2,450,000
Arlington Standpipe, . . . . .	550,000
Forbes Hill Standpipe, . . . . .	330,000
Weston Reservoir, . . . . .	200,000,000
Total, . . . . .	<hr/> 2,381,230,000

The grounds about the Chestnut Hill Reservoir, Spot Pond, Fells, Mystic and Forbes Hill reservoirs are kept in an attractive condition, and considerable expenditures have also to be made for the care of the driveways and shrubbery. There are many visitors to these grounds during the summer season, and the people are permitted to frequent them, subject to such regulations as are necessary for the purpose of keeping the grounds in proper order and preventing the pollution of the water.

Considerable work has been required at the Chestnut Hill Reservoir in the replacing and rebuilding of walks, and in the repairs and renewals for the various gate-houses. The water of the Mystic Reservoir was shut off, and the reservoir, for the first time in thirteen years, was thoroughly cleaned. Other repairs of a minor

nature have been required on various buildings and gate-houses connected with the various reservoirs.

Mystic Lake, having a capacity of 380,000,000 gallons, is not now used for purposes of water supply, but is maintained in good repair, and its waters may be used in case of emergency. The high-service reservoir in the city of Chelsea, by an arrangement made with the Water Commissioners of that city, may be used, if necessary, for supplying other cities and towns in the northern portion of the District. This reservoir has a capacity of 916,500 gallons.

The steel cylindrical structure constituting the Arlington standpipe is not enclosed by any surrounding framework or barrier, and is entirely unprotected. Standing at the top of Arlington Heights, it is seen from a great distance in all directions. It not only lacks the protection which such a permanent structure should be afforded, but presents an unsightly appearance for an important public work. The Board has recommended to the Legislature of the present year an appropriation for enclosing the standpipe with a masonry tower.

#### (4) AQUEDUCTS.

The Wachusett Aqueduct was in use 266 days during the year, and an average of 71,877,000 gallons per day was conveyed during the periods of its use to the Sudbury Reservoir. This aqueduct was closed for a thorough cleaning during 6 days. It has been the policy during the year to draw water from Lake Cochituate and the reservoirs on the Sudbury River when their supply is sufficient for the purpose and of acceptable quality, in order that the Wachusett Reservoir may be more speedily filled.

The Sudbury Aqueduct was in operation 359 days, it being shut off during the remaining days of the year for cleaning. An average of 75,384,000 gallons per day was conveyed through the aqueduct and discharged principally into Chestnut Hill Reservoir, but at times water was discharged into pipes leading to the pumping station. Many of the manhole openings, which were built at intervals along the aqueduct for access, were reconstructed in part and improved.

The Cochituate Aqueduct was in service on 249 days, and during the period when not in use the aqueduct was thoroughly cleaned. An average of 15,313,000 gallons per day was conveyed through the aqueduct, and, as in the Sudbury Aqueduct, discharged into the Chestnut Hill Reservoir or into pipes leading to the pumping station.



Several manholes have been improved in a manner similar to that which was adopted on the Sudbury Aqueduct.

In the Weston Aqueduct the work of cutting out and pointing cracks, which had developed soon after construction, begun in the previous year, was completed. Trees have been set out at the reservoir, and at one point dikes have been built in order to divert the water into a proper channel. The aqueduct was in use 302 days, and an average of 30,742,000 gallons per day was conveyed directly to the distributing pipes in the Metropolitan Water District.

#### (5) PUMPING STATIONS.

About 75 per cent. of all the water supplied to the Metropolitan Water District has been pumped at the Chestnut Hill high-service and low-service stations. The remainder of the water is not pumped, but is delivered by gravity from the Weston Aqueduct into the main pipes of the Distributing System. The total quantity of water pumped at all the stations, amounting to 35,986,230,000 gallons, was 1,024,140,000 gallons more than during the preceding year. From the Chestnut Hill low-service pumping station the water is pumped to the lower districts of Boston, Somerville, Chelsea, Malden, Medford, Everett and Arlington, and also to Spot Pond. The water is pumped from the Chestnut Hill high-service station to the higher districts of Boston, Quincy, Watertown, Belmont and a part of Milton. Water is pumped a second time from Spot Pond to Melrose, Revere, Winthrop, Nahant, Swampscott and the higher portions of Somerville, Chelsea, Malden, Medford and Everett, from a station in Arlington to Lexington and the higher portions of Arlington, and from a station in West Roxbury to the higher portions of West Roxbury and Milton. The quantity of water pumped in the Chestnut Hill low-service station was less than in the preceding year, but in all of the other stations there was an increase in the quantity, especially at the West Roxbury pumping station. At the latter station the increase was 26.2 per cent. over the preceding year. The quantity delivered from this station has become so great as nearly to equal the capacity of the station, and some action will soon be called for in order to give the requisite relief.

The cost of operating the stations was \$93,752.58, or \$2.605 per million gallons pumped, which was 1 cent less than the cost during the preceding year.

The cost per million gallons raised 1 foot was for the Chestnut Hill high-service station \$0.024, for the Chestnut Hill low-service station \$0.031, for the Spot Pond pumping station \$0.031, for the West Roxbury station \$0.192, for the Arlington station \$0.096. These prices differ, decreasing accordingly as the quantities of water pumped increase. There has been a very slight decrease in the cost of fuel. A greater amount of repair work than usual has been required at the Chestnut Hill high-service station, particularly on account of repairs which have been necessary in the smaller and older engines.

A contract has been made for a new pumping engine for the Arlington pumping station, and studies are in progress for the building of a new station in place of the temporary building which has been used since 1899.

Many tests have been made during the year in order to determine the qualities of the oils used at the various stations, and also to ascertain the heating power and values of all the kinds of coal which have been used.

#### (6) PIPE LINES AND PIPE YARDS.

But a single break occurred in the various pipe lines in operation throughout the District. This break, which occurred near the Chestnut Hill low-service pumping station, was caused by uneven settlement of the ground, and was repaired without disturbance and at a very small expenditure. There have been discovered and repaired during the year 16 leaks, the most serious troubles occurring in the crossings of the Mystic and Charles rivers. For the repair of the pipes at the river crossings the services of a diver were required, but otherwise all of the labor has been performed by the emergency and repair forces of the Metropolitan Works.

It has been necessary during the year to add two meters to the number of those, principally Venturi meters, which have been placed in the main pipe lines for the purpose of measuring the amounts of water supplied to the different cities and towns in the District. There are now in operation 56 of these meters. The operation and registration of these meters and maintenance in proper condition has required the care of two men.

## (7) SEWERAGE AND FILTRATION WORKS.

(a) *Clinton Sewerage Works.*

There was still a decrease in the amount of sewage received during the year at the Clinton Sewerage Works, about 97,000 gallons per day less being pumped and filtered than during the year 1904. Some of this decrease was undoubtedly due to the continued extension of the metering of water services in Clinton, by which the waste of water has been checked; but more is due to the comparatively small amount of water which has run in the river, and the consequent decrease in the amount entering leaky sewers which are located near the river. Experimentation has been continued during the year in methods of using the various filter-beds and caring for them. Although there was a considerable increase in the percentage of organic matter removed from the sewage, the character of the effluent from the filter-beds has remained about the same as in preceding years. Experiments will be continued for the purpose of increasing the efficiency of the system.

(b) *Marlborough Brook Filter-beds.*

The filter-beds at the head of the Sudbury Reservoir, which have been built to receive the water from the brook flowing through the city of Marlborough, and also those built to receive the contents of the overflow sewer which has recently been built, have been in successful use during the year, and they have properly filtered all the water received except for a few hours on a single day in the month of January. The beds have been subjected to cleaning, and certain repairs and improvements in the system have been made. The water entering the reservoir has generally been satisfactorily purified by the filtration.

(c) *Pegan Brook Filtration Works.*

The filter-beds receiving the water of Pegan Brook, which is polluted by flowing through portions of the town of Natick, have been in operation during 202 days. The storage reservoirs built to receive the flow of the brook and of the intercepting ditch, together with the pumps, were sufficient, except on parts of 6 days, to dispose of all the waters coming from Pegan Brook and the intercepting



ditch which was dug around the portion of Lake Cochituate adjacent to the Pegan Brook meadows. During the year 235,317,000 gallons of water were pumped from the reservoir on to the filter-beds.

#### (8) SANITARY WORK AND REGULATIONS.

The general inspection of the Wachusett, Sudbury and Cochituate watersheds has continued to be exercised during the year under the supervision of William W. Locke, C.E., with two regular assistants; and laborers and others have been employed from time to time to carry out the improvements and changes which have been ordered. The services of Dr. J. J. Goodwin of Clinton, who had for several years successfully inspected the camps and other buildings occupied by laborers in construction work, were dispensed with in the latter part of the year, on account of the near completion of the contract work at the Wachusett Reservoir.

There were no cases of infectious disease arising within the Wachusett Reservoir lands. There were, however, some cases of typhoid fever within the limits of the Wachusett watershed. As soon as the cases were reported they were at once investigated, and measures were taken by which no pollution should reach any stream entering the reservoir. There was a somewhat larger number of cases of typhoid fever in the Sudbury and Cochituate watersheds, but nothing occurred to endanger the purity of the water supply. It is an interesting fact that during the entire eight years of contract work upon the site of the Wachusett Reservoir very little sickness has developed among the laborers or their families, and there have been among them but 13 cases of typhoid fever during the entire period. This is the more notable inasmuch as there have been employed on an average about 1,200 men during all this period of construction, and with many of these laborers have lived their families.

On the Wachusett watershed there were inspected during the year 1,452 premises, for the purpose of ascertaining whether there were any conditions which needed correction or improvement, the investigations being directed particularly to cesspools, privy and sink drainage, manure piles and manufacturing wastes. Of these, 1,257 were declared satisfactory at the end of the year, and 195 unsatisfactory. Remedies were effected in 74 cases, and 13 cases were partially remedied, largely by the building of new cesspools and cemented vaults. On the Sudbury and Cochituate watersheds

7,480 premises were inspected, and at the end of the year 7,119 were declared satisfactory, and 361 unsatisfactory. Remedy by sewer connection was obtained in 161 cases. There were remedied otherwise 10 premises; 61 premises were partially remedied; and 144 cesspools were abandoned on account of the sewer connections. Much improvement has also been effected in both watersheds by the burning, tearing down or removal of old buildings.

The various drainage ditches in these watersheds have been kept in good order and repair, and have been properly cleaned.

It has been deemed proper to acquire by purchase one of the larger mill properties situated on the Quinepoxet River in that portion of the town of Holden lying near the reservoir, and two or three other small mills, the situation of which was such as particularly to endanger the quality of the water supply, have also been acquired.

A new sanitary census of all the watersheds, which had been begun in the year 1904, was completed during the past year. There appear to be in the Wachusett watershed, embracing an area of 118.31 square miles, 1,658 dwellings and other occupied buildings, 102 vacant buildings and 273 summer cottages; and upon this area there is a permanent population of 5,772, and a summer population of 1,900 in addition. The permanent population is 49 per square mile, and the total combined permanent and summer population is 65 per square mile.

Upon the Sudbury watershed, having an area of 75.20 square miles, there are 4,607 occupied buildings and 303 vacant buildings, with a total population of 21,131, of whom 10,575 occupy dwellings not connected with sewers. This area has a population per square mile of 281, and the population per square mile in dwellings not connected with sewers is 141.

On the Cochituate watershed, having an area of 19.84 square miles, there are 2,873 occupied buildings and 74 vacant buildings, and there is a population of 15,508, of whom 6,521 occupy dwellings not connected with sewers. The population per square mile is 782, and the population occupying dwellings not connected with sewers is 329 per square mile. The figures above given for the Cochituate watershed do not include 71 small cottages and camps on the shores of Lake Cochituate, with a population of 214 on August 1, 1905.

Beside the regular examination of samples of water collected from the various points on the works, made by the State Board of



Health, collections of samples are made weekly from many points, and these are examined by the biological force of the Board microscopically, and for color, odor, taste and turbidity. During the year 2,595 microscopical and 604 bacterial examinations were thus made.

Boating and fishing in Lake Cochituate have so increased within the past few years that the Board has felt compelled to take some action for the preservation of the purity of the water. Although a margin around the lake is owned by the Commonwealth, this margin is narrow, and cottages are built in close proximity to the lake. The number of these cottages has greatly increased even during the past year. The attention of buyers has been publicly called to small lots laid out for sale, and propositions have been made for the establishment of large recreation and picnic grounds in the immediate vicinity of the lake. Land adjacent to the margins has also been more and more leased for short periods to campers, who erect tents and adopt practices which are far from sanitary in their nature. These various inducements held out were attracting to the lake persons coming largely from places outside of the immediate neighborhood.

As water for the supply of the Metropolitan District is drawn from the northern division of the lake, the section situated north of the county road known as Lake Avenue, and is delivered from the aqueduct for a portion of the time directly into the distributing pipes of the District, the Board determined it to be necessary to prohibit, on and after January 1, 1906, boating and fishing in this division of the lake.

It has, however, been the desire of the Board that the remainder of the lake should still be used for boating and fishing by those having permanent cottages about the lake, and the neighboring residents, so far as is consistent with the preservation of the purity of the water. Provision has been made for the registration of all boats which shall be used upon the lake, in order that they may be brought more under the observation and supervision of the agents of the Board. Licenses are also to be issued for the use of the boats thus registered; and beginning with the year 1906 boating is to be permitted only for the season extending from April 1 to September 20, inclusive. The limit in number of boats to be registered has been fixed at 125, and in the registration of the boats consideration is to be given to the question of the residence of the applicant, whether in



the neighborhood of the lake or otherwise, and of his ownership of a cottage or permanent camp now existing.

Applications for registration of boats are to be made to the Assistant Superintendent of the Metropolitan Water Works at South Framingham, for which blanks are furnished by the Board. It is required that the applicant shall state the character of the boat, its length, color, name, if any, and the owner's name, residence and post-office address, and the place where the boat is to be kept. He is also to state the names, residence and relationship to the owner of the persons to whom he desires licenses to be given for the use of the boat, the licenses to be limited to the owners and immediate members of their families. It is provided that the boat when used shall be in charge of one of the licensees, and shall not be let or be used for the carrying of passengers for compensation. A fee of \$1 is required for registration, and the owner receives a plate bearing a number, which must be attached to the boat in such position as required by the agent of the Board, and which must always be kept in sight. Registration is, of course, revokable by the Board in case of any violation of the rules or requirements of the Board.

Fishing is permitted during the season above mentioned, in the sections of the lake situated squtherly from Lake Avenue, in boats which have been duly registered and numbered and are used in accordance with the requirements of the Board. Permission is also given to enter from the highway and fish in the lake during the same season, and to enter from the highway and fish through the ice in the same portion of the waters of the lake at other seasons.

The Board trusts that with the adoption of such measures the lake may be used by those who should more properly be entitled to the use, in a manner which shall not injure the purity of the water as a source of water supply.

#### (9) QUALITY OF THE WATER.

The quality of the water has been satisfactory and has been substantially the same as for the preceding two years. At times, particularly in the autumn, microscopic organisms were found more than usually abundant in one or another of the reservoirs, and the water has at times acquired a somewhat more noticeable taste and odor, although these organisms have not been at all injurious to the public health. There has been little or no complaint from water

takers during the year. With the filling of the Wachusett Reservoir and the opportunity afforded for longer storage, it is anticipated that there will be in the near future a still greater improvement in the quality of the water.

#### (10) THE WATER SUPPLY.

Owing to the small rainfall, especially at the season of the year when water is collected in the reservoirs, the yield of the various watersheds has been very small in comparison with that of the preceding years. The total rainfall on the Sudbury watershed was 3.78 inches below the average, and the yield of the watershed was 26 per cent. below the average of the preceding thirty years. The rainfall on the Wachusett watershed was 5.77 inches below the average, and the yield of the watershed was also 27 per cent. less than the average of the preceding eight years during which records have been kept.

Water was supplied during the year to all of the cities and towns embraced within the Metropolitan Water District, except the city of Newton and the town of Hyde Park. Water was also supplied to the town of Swampscott, which is without the limits of the District, by a special agreement made with that town; and a small part of the town of Saugus is supplied by the town of Revere, under an arrangement with the Board. The estimated population, as of July 1, 1905, supplied with water was 902,090. The town of Revere was supplied with water by the Revere Water Company until April 1, 1905, at which time the town acquired the works of water supply, and since that date the town has directly supplied its inhabitants.

The city of Newton and the town of Hyde Park have as yet made no application for a supply of water, and, the Board being of the opinion that these municipalities have not reached the safe capacities of their own sources of supply in a dry year, they have been charged, in accordance with the Metropolitan Water Act, but one-sixth of the entire assessment which they would have been called upon to pay had they received a water supply from the Metropolitan sources.

The water supplied by the Metropolitan Water System to the various cities and towns amounted to a total of 43,215,210,000 gallons, an average daily supply of 118,398,000 gallons, and a daily

average of 131 gallons for each inhabitant. The city of Newton and the town of Hyde Park supplied from their own sources to their respective inhabitants a total of 1,194,567,400 gallons, being a daily average of 63 gallons per inhabitant.

The city of Cambridge again made a request for a temporary supply of water, on account of its inability to obtain a sufficiency of proper water for domestic purposes from its own works. The city was proceeding with proper diligence in the laying of a new pipe line to relieve its necessities; but, the season being much drier than could have been anticipated, it had become impossible for the city to obtain a sufficient supply for the time being from its own works without lowering Fresh Pond to such an extent as to threaten the public health. The evidence of physicians and experts was presented to the Board, showing that the health of the inhabitants of that city would be seriously menaced if the water continued to be drawn from the pond without reinforcement from other sources. Although the city of Cambridge had not obtained any legislation, as had been expected, by which the temporary furnishing of water should be authorized by statute in case of emergency, the Board reached the opinion that the situation was so dangerous that it would not be justified in refusing to grant still another temporary supply, particularly as no injury or detriment could come to the Metropolitan District thereby. Accordingly, 269,170,000 gallons of water were furnished to that city from August 4 to September 6, the water being supplied at such times and in such quantities as the Board determined, and subject to the same limitations and restrictions as applied to the cities and towns of the Metropolitan Water District. The Board received for this temporary supply the sum of \$13,458.50.

The town of Wakefield was compelled for about a week in the month of October to suspend the operation of its works for the purpose of making necessary changes and repairs, and for this purpose 4,000,000 gallons of water were supplied to that town. Arrangements have also been made for supplying water to the United States Government reservation on Peddock's Island, through pipes which are laid to the island from Hough's Neck and across Nut Island in Quincy, and during the past year there were so supplied 1,608,000 gallons.



## V. WATER WORKS — FINANCIAL STATEMENT.

The Metropolitan Water Loans authorized for the construction and acquisition of works have amounted to \$40,000,000. To this sum are added the proceeds from the sale of certain property by the Board, and these amounted on January 1, 1906, to \$123,765.50. The total amount, therefore, which the Board has been authorized to expend is \$40,123,765.50. The amount of expenditures approved by the Board for payment out of the Metropolitan Water Loan Fund was, for the year 1905, \$655,958.47; and the total amount so approved for payment since the beginning of the work up to January 1, 1906, has been \$39,044,214.23. There was accordingly a balance remaining at the beginning of the year amounting to \$1,079,551.27.

The Treasurer of the Commonwealth has issued from time to time, on the request of the Board, bonds to the amount of \$39,150,000. These bonds were issued for terms of 39½ and 40 years from the date of issue, and bear interest at the rate of 3 per cent. and 3½ per cent. per annum. The sinking fund established for the payment of the bonds at maturity amounted on January 1, 1906, to \$4,207,045.69.

The amount approved by the Board for the maintenance and operation of the Water Works for the year 1905, which was paid out of the annual assessments, was \$318,677.57.

The assessments for the year 1905 for the payment of interest on the bonds, for the sinking fund requirements, and for the expenses of operation and maintenance of the Water Works, which were levied upon the various cities and towns in the Metropolitan District, amounted to \$2,177,586.39.

Receipts from sales of water to municipalities not belonging to the District and to water companies were distributed back to the cities and towns, in proportion to their respective assessments, to the amount of \$19,764.25.

The detailed financial statement regarding the Metropolitan Water Works is as follows: —

## (1) METROPOLITAN WATER LOANS, RECEIPTS AND PAYMENTS.

The loans for the construction and acquisition of the Metropolitan Water Works, the receipts which are added to the proceeds of these loans, the expenditures for the construction and acquisition

of works, and the balance available on January 1, 1906, have been as follows : —

Loan under chapter 488 of the Acts of 1895,	. . . . .	\$27,000,000 00
Loan under chapter 453 of the Acts of 1901,	. . . . .	13,000,000 00
		<hr/>
		\$40,000,000 00
Proceeds from the sales of property applicable to the construction and acquisition of works (of which \$28,194.65 is for the year 1905),	. . . . .	123,765 50
		<hr/>
		\$40,123,765 50
Amount approved by the Metropolitan Water and Sewerage Board for payments to December 31, 1905 (of which \$655,958.47 is for the year 1905),	. . . . .	39,044,214 23
		<hr/>
Balance January 1, 1906,	. . . . .	\$1,079,551 27

(2) ISSUES OF METROPOLITAN WATER LOAN BONDS.

The Treasurer of the Commonwealth, under the authority given him to issue from time to time, on the request of the Board, negotiable bonds to an amount not exceeding \$40,000,000, to be designated the “Metropolitan Water Loan,” has sold bonds as follows : —

DATE OF SALE.	Amount of Bonds sold.	Rate of Interest (per cent.).	Price received.	Date due.	Premium.
Sept. 25, 1895,	\$5,000,000	3½	110.67	July 1, 1935,	\$533,500 00
Nov. 23, 1896,	2,000,000	3½	106.76268	July 1, 1935,	135,253 60 <sup>1</sup>
Feb. 8, 1897,	6,000,000	3½	107.82	July 1, 1935,	469,200 00
Jan. 13, 1898,	2,000,000	3½	113.176	Jan. 1, 1938,	263,520 00
Mar. 2, 1898,	2,000,000	3½	112.877	Jan. 1, 1938,	257,540 00
June 15, 1899,	3,000,000	3	100.64	July 1, 1939,	19,200 00
June 28, 1900,	1,000,000	3	102.78	July 1, 1939,	27,800 00
Mar. 5, 1901,	3,000,000	3	102.155	Jan. 1, 1941,	64,650 00
July 24, 1901,	100,000	3	100.375	Jan. 1, 1941,	375 00
July 24, 1901,	150,000	3	100.10	Jan. 1, 1941,	150 00
July 30, 1901,	205,000	3	100.25	Jan. 1, 1941,	512 50
July 31, 1901,	50,000	3	100.25	Jan. 1, 1941,	125 00
Aug. 7, 1901,	50,000	3	100.50	Jan. 1, 1941,	250 00
Aug. 8, 1901,	300,000	3	100.10	Jan. 1, 1941,	300 00
Aug. 8, 1901,	200,000	3	100.25	Jan. 1, 1941,	500 00
Sept. 17, 1901,	3,100,000	3½	106.71	Jan. 1, 1941,	208,010 00
Oct. 1, 1901,	1,345,000	3	100.	Jan. 1, 1941,	-
Oct. 24, 1901,	1,500,000	3	100.	Jan. 1, 1941,	-
Feb. 26, 1902,	500,000	3½	109.13	Jan. 1, 1942,	45,650 00
Feb. 26, 1902,	3,000,000	3½	109.13	Jan. 1, 1942,	273,900 00
April 7, 1903,	250,000	3½	106.725	Jan. 1, 1943,	16,812 50
April 17, 1903,	1,250,000	3½	106.1329	Jan. 1, 1943,	76,661 25
Jan. 15, 1904,	500,000	3½	104.60	Jan. 1, 1943,	23,000 00
Jan. 15, 1904,	2,000,000	3½	104.60	Jan. 1, 1944,	92,000 00
Mar. 24, 1905,	650,000	3½	105.761	Jan. 1, 1945,	37,446 50
	<hr/>				
	\$39,150,000				\$2,546,356 35

<sup>1</sup> Including \$18,673.60 from readjustment of rate made by the Treasurer in 1897.

## (3) METROPOLITAN WATER LOAN SINKING FUND.

The sinking fund established by the Treasurer of the Commonwealth has amounted at the end of each year to sums as follows : —

December 31, 1895,	. . . . .	\$226,286 05
December 31, 1896,	. . . . .	699,860 70
December 31, 1897,	. . . . .	954,469 00
December 31, 1898,	. . . . .	1,416,374 29
December 31, 1899,	. . . . .	1,349,332 97
December 31, 1900,	. . . . .	1,573,619 72
December 31, 1901,	. . . . .	1,662,426 95
December 31, 1902,	. . . . .	2,256,803 81
December 31, 1903,	. . . . .	2,877,835 59
December 31, 1904,	. . . . .	3,519,602 92
December 31, 1905,	. . . . .	4,207,045 69

## (4) ANNUAL ASSESSMENTS AND RECEIPTS.

Assessments for the year, amounting to \$2,177,586.39, were required for the payment of the interest on the bonds issued by the Commonwealth, the sinking fund requirements and the expenses of operation and maintenance of the Water Works. The requirements were: for interest, \$1,335,393.91; for the sinking fund, \$513,568.32; and for maintenance and operation, \$328,624.16. These assessments were made by the Treasurer of the Commonwealth upon the various municipalities as follows : —

Arlington, . . . . .	\$13,486 46	Nahant, . . . . .	\$3,699 67
Belmont, . . . . .	6,637 30	Newton, . . . . .	10,699 51
Boston, . . . . .	1,758,635 00	Quincy, . . . . .	35,832 50
Chelsea, . . . . .	46,418 14	Revere, . . . . .	16,412 09
Everett, . . . . .	35,081 32	Somerville, . . . . .	90,560 73
Hyde Park, . . . . .	3,256 77	Stoneham, . . . . .	8,662 33
Lexington, . . . . .	6,679 80	Watertown, . . . . .	15,689 53
Malden, . . . . .	49,720 51	Winthrop, . . . . .	10,424 06
Medford, . . . . .	28,631 54		
Melrose, . . . . .	20,478 53		
Milton, . . . . .	16,580 60		
			<hr/>
			\$2,177,586 39

The comparatively smaller sums assessed upon the city of Newton and the town of Hyde Park were owing to the fact that neither of these municipalities had reached the safe capacity of its sources, and had been furnished with water.



The proceeds from the operations of the Board, exclusive of the proceeds from sales of property, are, in accordance with the provisions of the Water Act, applied to the reduction of the assessment, and these, for the year 1905, amounted to \$7,708.27.

The actual expenditures for the maintenance and operation of the Metropolitan Water Works were, for the year 1905, \$318,677.57.

(5) DISTRIBUTION TO CITIES AND TOWNS OF SUMS RECEIVED FROM WATER FURNISHED TO OTHER MUNICIPALITIES.

Sums have been received during the year 1905, under the provisions of the Metropolitan Water Act, for water furnished, as follows : —

Cambridge, . . . . .	\$28,458 50
Framingham Water Company, . . . . .	387 10
Revere, . . . . .	164 25
Revere Water Company, . . . . .	54 75
Swampscott, . . . . .	4,600 00
	<hr/>
	\$33,664 60

The Treasurer, in accordance with the requirements of the Act, distributed to the cities and towns of the District, in proportion to the annual assessments theretofore contributed by them, a part of this amount, as follows : —

Arlington, . . . . .	\$114 55	Nahant, . . . . .	\$32 78
Belmont, . . . . .	59 09	Newton, . . . . .	96 71
Boston, . . . . .	16,163 59	Quincy, . . . . .	316 39
Chelsea, . . . . .	423 38	Revere, . . . . .	141 79
Everett, . . . . .	305 70	Somerville, . . . . .	809 65
Hyde Park, . . . . .	28 76	Stoneham, . . . . .	64 60
Lexington, . . . . .	28 28	Watertown, . . . . .	139 39
Malden, . . . . .	436 91	Winthrop, . . . . .	88 02
Medford, . . . . .	256 94		<hr/>
Melrose, . . . . .	185 45		\$19,764 25
Milton, . . . . .	72 27		

(6) EXPENDITURES FOR THE DIFFERENT WORKS.

The following is a summary of the expenditures made in the various operations for the different works : —

CONSTRUCTION AND ACQUISITION OF WORKS.	For the Year ending December 31, 1905.	From Beginning of Work to December 31, 1905.
Administration applicable to all parts of the construction and acquisition of the works, . . . . .	\$12,595 94	\$251,674 69
Wachusett Dam and Reservoir :—		
Wachusett Dam, . . . . .	\$109,492 43	\$2,182,644 42
North Dike, . . . . .	2,219 85	749,508 30
South Dike, . . . . .	19,755 53	135,296 84
Removal of soil, . . . . .	153,361 43	2,491,419 39
Relocation of railroads, . . . . .	39,088 55	860,789 32
Roads and bridges, . . . . .	44,721 28	529,196 53
Real estate, . . . . .	40,559 83	3,181,630 38
Damages, real estate not taken, business and loss of wages, . . . . .	24,701 08	494,267 50
Other expenses, . . . . .	1,090 70	6,472 92
	524,990 68	10,631,225 60
Improving Wachusett watershed, . . . . .	7,164 86	66,089 67
Wachusett Aqueduct, . . . . .	3,362 58	1,793,600 20
Sudbury Reservoir, . . . . .	—	2,922,445 21
Protection of Sudbury supply, . . . . .	—	128,797 06
Improving Sudbury watershed, . . . . .	352 35	95,106 93
Protection of Cochituate supply, . . . . .	—	9,000 00
Improving Cochituate watershed, . . . . .	—	8,860 68
Improving Lake Cochituate, . . . . .	—	103,537 29
Pipe lines, Dam No. 3 to Dam No. 1, . . . . .	—	48,471 48
Pipe line, Rosemary siphon, . . . . .	—	23,142 98
Weston Aqueduct :—		
Aqueduct, . . . . .	\$33,952 35	\$2,349,963 12
Reservoir, . . . . .	4,847 31	288,302 10
Supply pipe lines, . . . . .	317 86	584,351 78
Real estate, taxes and other expenses, . . . . .	18,969 97	203,121 21
	58,087 49	3,425,738 21
Distribution system :—		
Low service :—		
Pipe lines and connections, . . . . .	—	\$1,751,205 67
Pumping station, Chestnut Hill, . . . . .	—	459,251 97
Reservoir, Spot Pond, . . . . .	—	578,101 58
Gate-house and connections, Chestnut Hill Reservoir, . . . . .	—	65,480 88
Real estate and other expenses, . . . . .	\$4,100 77	90,910 66
Northern high service :—		
Pipe lines and connections, . . . . .	—	440,539 28
Spot Pond pumping station, . . . . .	—	291,829 35
Fells Reservoir, Stoneham, . . . . .	—	141,392 94
Bear Hill Reservoir, Stoneham, . . . . .	—	38,267 70
Real estate and other expenses, . . . . .	—	14,838 05
Southern high service :—		
Pipe lines and connections, . . . . .	5,124 86	509,546 41
Pumping station, Chestnut Hill, . . . . .	—	242,121 35
Forbes Hill Reservoir, Quincy, . . . . .	—	90,003 49
Waban Hill Reservoir, Newton, . . . . .	—	61,592 11
Real estate and other expenses, . . . . .	—	10,226 36
Amounts carried forward,	\$9,225 63 \$606,553 90	\$4,785,306 80 \$19,507,690 00

CONSTRUCTION AND ACQUISITION OF WORKS.	For the Year ending December 31, 1905.		From Beginning of Work to December 31, 1905.	
<i>Amounts brought forward,</i> . . .	\$9,225 63	\$606,553 90	\$4,785,306 80	\$19,507,690 00
Distribution system — <i>Con.</i>				
Northern extra high service, . . .	76 68		14,028 15	
Southern extra high service, . . .	—		22,815 67	
Meters and connections, . . .	1,495 72		76,397 00	
Improving Spot Pond Brook, . . .	—		3,717 05	
Glenwood pipe yard, . . .	—		33,100 59	
Chestnut Hill pipe yard, . . .	—		11,311 26	
		10,798 03		4,946,676 52
Diversion of water, South Branch of Nashua River, <sup>1</sup> . . .		379 69		1,357,811 00
Acquisition of existing water works:—				
Reimbursement city of Boston, partially constructed Sudbury Reservoir, . .	—		\$1,157,921 59	
To Boston, for works taken Jan. 1, 1898, .	—		12,768,948 80	
To Malden, Medford and Melrose (on ac- count) for taking of Spot Pond, . .	—		343,570 39	
To Newton, for Waban Hill Reservoir, .	—		60,000 00	
			\$14,330,440 78	
Transfers of works acquired and other prop- erty to accounts for special works, . .	—		1,240,221 94	
			\$13,090,218 84	
Engineering, conveyancing, etc., . . .		36,711 68	70,526 22	13,160,745 06
<i>Pipes, Valves, Castings, etc., sent First to Storage Yards, and afterwards transferred as needed to Different Parts of the Work.</i>				
Sent to storage yards, . . .	\$2,033 47		\$2,086,469 96	
Transferred from storage yards to works, and included in costs above, . . .	518 30		2,015,178 31	71,291 65
		1,515 17		
Total for constructing and acquiring of works, . . .		\$655,958 47		\$39,044,214 23

<sup>1</sup> Of the total expenditures from the beginning of the work, the sum of \$149,432.86 is for Clinton sewerage system.

MAINTENANCE AND OPERATION.	For the Year ending December 31, 1905.	
Administration, . . .		\$11,005 91
General supervision, . . .		4,431 40
Taxes and other expenses, . . .		29,897 73
Wachusett Reservoir Department:—		
General superintendence, . . .	\$424 52	
Sanitary inspection, . . .	1,787 15	
Buildings, . . .	1,519 02	
Reservoir, . . .	10,289 13	
		14,019 82
<i>Amount carried forward,</i> . . .		\$59,354 86



MAINTENANCE AND OPERATION.	For the Year ending December 31, 1905.	
<i>Amount brought forward,</i> . . . . .		\$59,354 86
<b>Wachusett Dam and Aqueduct Department:—</b>		
General superintendence, . . . . .	\$1,225 15	
Dam and aqueduct, . . . . .	8,970 05	
<b>Clinton sewerage system:—</b>		
Pumping station, . . . . .	2,582 72	
Sewers, screens and filter-beds, . . . . .	2,924 89	
Sanitary inspection, . . . . .	1 00	
		15,703 81
<b>Sudbury Department:—</b>		
General superintendence, . . . . .	\$3,978 33	
Superintendence, Framingham office, . . . . .	6,970 18	
Ashland Reservoir, . . . . .	2,044 08	
Hopkinton Reservoir, . . . . .	2,260 25	
Whitehall Reservoir, . . . . .	280 34	
Framingham Reservoirs, 1, 2 and 3, . . . . .	4,749 35	
Sudbury Reservoir, . . . . .	5,196 15	
Lake Cochituate, . . . . .	3,551 23	
Marlborough Brook filters, . . . . .	2,928 00	
Pegan filters, . . . . .	2,598 02	
Sudbury and Cochituate watersheds, . . . . .	901 41	
Sanitary inspection, . . . . .	2,460 54	
Cochituate Aqueduct, . . . . .	5,678 71	
Sudbury Aqueduct, . . . . .	10,720 58	
Weston Aqueduct, . . . . .	15,619 67	
Biological laboratory, . . . . .	2,730 01	
		72,666 85
<b>Distribution Department:—</b>		
Superintendence, . . . . .	\$10,745 30	
Arlington pumping station, pumping service, . . . . .	5,880 60	
Chestnut Hill low-service pumping station, pumping service, . . . . .	32,279 38	
Chestnut Hill high-service pumping station, pumping service, . . . . .	37,298 30	
Spot Pond pumping station, pumping service, . . . . .	11,029 91	
West Roxbury pumping station, pumping service, . . . . .	6,916 26	
Arlington standpipe, . . . . .	1 60	
Bear Hill Reservoir, . . . . .	109 34	
Chelsea Reservoir, . . . . .	7 65	
Chestnut Hill Reservoir, . . . . .	9,118 30	
Fells Reservoir, . . . . .	730 94	
Forbes Hill Reservoir, . . . . .	1,181 19	
Mystic Lake, conduit and pumping station, . . . . .	2,235 98	
Mystic Reservoir, . . . . .	2,016 53	
Waban Hill Reservoir, . . . . .	472 32	
Weston Reservoir, . . . . .	1,725 12	
Spot Pond, . . . . .	12,499 88	
Buildings at Spot Pond, . . . . .	524 98	
<b>Pipe lines:—</b>		
Low service, . . . . .	10,928 54	
Northern high service, . . . . .	4,508 22	
Southern high service, . . . . .	2,885 48	
Supply pipe lines, . . . . .	779 82	
<i>Amounts carried forward,</i> . . . . .	\$153,875 64	\$147,725 52

MAINTENANCE AND OPERATION.		For the Year ending December 31, 1905.	
<i>Amounts brought forward,</i> . . . . .		\$153,875 64	\$147,725 52
Distribution Department — <i>Con.</i>			
Buildings at Chestnut Hill, . . . . .		1,456 76	
Chestnut Hill pipe yard, . . . . .		963 04	
Glenwood pipe yard and buildings, . . . . .		4,118 43	
Stables, . . . . .		4,698 57	
Waste prevention, . . . . .		2,583 57	
Venturi meters, . . . . .		3,256 04	
			170,952 05
Total for maintaining and operating works, . . . . .			\$318,677 57

(7) DETAILED FINANCIAL STATEMENT UNDER METROPOLITAN  
WATER ACT.

The Board herewith presents, in accordance with the requirements of the Metropolitan Water Act, a detailed statement of the expenditures and disbursements, receipts, assets and liabilities for the year 1905.

(a) *Expenditures and Disbursements.*

The total amount of the expenditures and disbursements on account of construction and acquisition of works for the year beginning January 1, 1905, and ending December 31, 1905, is \$655,958.47; and the total amount from the time of the organization of the Metropolitan Water Board, July 19, 1895, to December 31, 1905, is \$39,044,214.23.

For maintenance and operation the expenditures for the year have been \$318,677.57, and from the beginning of the work, \$2,231,214.01.

The salaries of the commissioners, and other expenses of administration, have been apportioned to the construction of the works and to the maintenance and operation of the same, and appear under each of those headings.

The following is a division of the expenditures according to their general character : —

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1905.	From Beginning of Work to December 31, 1905.
<b>CONSTRUCTION OF WORKS AND ACQUISITION BY PURCHASE OR TAKING.</b>		
<i>Administration.</i>		
Commissioners, . . . . .	\$4,666 66	\$105,643 58
Secretary and auditor, . . . . .	1,601 92	45,717 03
Clerks and stenographers, . . . . .	3,283 98	52,508 13
Legal services, . . . . .	-	2,359 00
Travelling, . . . . .	181 99	3,591 08
Stationery and printing, . . . . .	1,510 11	10,182 09
Postage, express and telegrams, . . . . .	64 60	2,627 97
Furniture and fixtures, . . . . .	147 45	4,280 89
Alterations and repairs of buildings, . . . . .	-	5,743 27
Telephone, lighting, heating, water and care of building, . . . . .	617 69	10,355 63
Rent and taxes, main office, . . . . .	420 00	4,275 80
Miscellaneous expenses, . . . . .	101 54	4,390 22
	\$12,595 94	\$251,674 69
<i>Engineering.</i>		
Chief engineer and department engineers, . . . . .	\$9,302 24	\$202,410 23
Principal assistant engineers, . . . . .	8,434 65	145,225 49
Engineering assistants, . . . . .	38,431 62	984,705 40
Consulting engineers, . . . . .	123 00	23,560 07
Inspectors, . . . . .	8,290 55	289,645 89
Architects, . . . . .	2,671 14	35,199 53
Railroad and street car travel, . . . . .	129 04	26,735 19
Wagon hire, . . . . .	1,083 89	43,856 85
Stationery and printing, . . . . .	669 21	25,466 29
Postage, express and telegrams, . . . . .	122 51	7,575 36
Engineering and drafting instruments and tools, . . . . .	15 00	19,240 73
Engineering and drafting supplies, . . . . .	587 67	24,504 15
Books, maps and photographic supplies, . . . . .	256 15	6,625 59
Furniture and fixtures, . . . . .	100 49	14,977 46
Alterations and repairs of buildings:—		
Main office, . . . . .	1 50	13,939 86
Sub-offices, . . . . .	78 29	2,938 36
Telephone, lighting, heating, water and care of buildings:—		
Main office, . . . . .	1,968 71	21,827 39
Sub-offices, . . . . .	1,002 14	18,449 16
Rent and taxes, — main office, . . . . .	1,260 00	12,595 75
Rent of sub-offices and other buildings, . . . . .	-	4,513 74
Field offices and sheds, . . . . .	-	1,274 49
Clinton office building, . . . . .	-	9,866 87
Unclassified supplies, . . . . .	35 57	8,211 10
Miscellaneous expenses, . . . . .	82 06	8,534 27
	74,645 43	1,951,879 22
<i>Amounts carried forward,</i> . . . . .	\$87,241 37	\$2,203,553 91



GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1905.	From Beginning of Work to December 31, 1905.
<i>Amounts brought forward,</i> . . . .	\$87,241 37	\$2,203,553 91
<i>Construction.</i>		
Preliminary work (borings, test pits and other investigations):—		
Advertising, . . . . .	\$117 67	\$6,306 22
Other preliminary work as given in detail in preceding annual report, . . . .	75	155,457 41
	118 42	161,763 63
Contracts, Wachusett Reservoir:—		
Contracts completed and final payments made prior to January 1, 1905, . . . .	-	\$2,561,668 95
Busch Bros., excavating soil, Sect. 6, and building road, West Boylston and Boylston,—\$600 due, deducted from estimate, September 5, 1900, . . . . .	-	34,560 63
Newell & Snowling Construction Co., building a part of Newton Street and improving Crescent Street, West Boylston, . . . .	\$4,812 25	4,812 25
The H. Gore Co., surfacing highways, West Boylston, Sect. 1, . . . . .	6,457 27	6,457 27
The H. Gore Co., surfacing highways, West Boylston, Sect. 2, . . . . .	8,058 67	8,058 67
Bruno, Salomone & Petitti, Sect. 10, Wachusett Reservoir, Boylston and West Boylston, . . . . .	92,884 65	517,653 21
McArthur Bros. Co., building Sect. 2 of the relocation of Central Massachusetts Railroad, . . . . .	25,850 05	272,289 39
Francis A. McCauliff, masonry arch bridge at West Boylston, . . . . .	-	11,233 09
McBride & Co., Stillwater improvement, . . . . .	23,314 67	23,314 67
Sundry bills paid under this contract, . . . . .	3,163 05	3,163 05
John F. Magee & Co., South Dike, . . . . .	19,854 09	137,888 54
McArthur Bros. Co., riprap at South Dike, . . . . .	15,385 24	15,385 24
McArthur Bros. Co., Wachusett Dam, . . . . .	135,449 26	1,559,389 74
Gibby Foundry Co., castings for Wachusett Dam, . . . . .	1,331 10	2,536 63
Connery & Wentworth, superstructure of lower gate-chamber of the Wachusett Dam, . . . . .	16,966 14	72,937 34
American Tube Works, brass tubing for railing at Wachusett Dam, . . . . .	2,192 06	2,192 06
	355,718 50	5,233,540 73
Contracts completed, Wachusett Aqueduct, . . . . .	-	1,447,208 55
Contracts completed, Sudbury Reservoir, . . . . .	-	1,545,028 33
Contracts completed, protection Sudbury Supply:—		
City of Marlborough, main sewer, . . . . .	-	9,000 00
Contracts completed, improving Lake Cochituate, . . . . .	-	60,657 45
<i>Amounts carried forward,</i> . . . . .	\$443,078 29	\$10,660,752 60

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1905.	From Beginning of Work to December 31, 1905.
<i>Amounts brought forward,</i> . . . .	\$443,078 29	\$10,660,752 60
<i>Construction — Con.</i>		
Contracts completed, protection Cochituate Supply:—		
Town of Framlingham, low-level sewer, . .	-	9,000 00
Contracts completed, Rosemary siphon, . .	-	5,916 96
Contracts completed, pipe line, Dam No. 3 to Dam No. 1, . . . . .	-	17,240 22
Contracts completed, Clinton sewerage sys- tem, . . . . .	-	66,878 22
Contracts, Weston Aqueduct:—		
Contracts completed and final payments made prior to January 1, 1905, . . . .	-	\$1,448,087 96
Shanahan, Casparis & Co., . . . Sect. 2,	\$4,182 57	201,827 74
Sundry bills paid under this contract, . .	-	2,911 80
Shanahan, Casparis & Co., . . . Sect. 3,	4,140 28	126,420 70
Sundry bills paid under this contract, . .	-	4,214 78
Shanahan, Casparis & Co., . . . Sect. 6,	2,127 60	108,933 26
Sundry bills paid under this contract, . .	-	6,968 05
Winston & Co., . . . Sects. 8 and 10,	3,549 68	150,101 77
Shanahan, Casparis & Co., . . . Sect. 12,	2,970 00	138,151 78
Sundry bills paid under this contract, . .	-	3,339 77
Winston & Co., . . . . . Sect. 15,	14,731 62	183,374 58
	31,701 75	2,374,332 19
Contracts, Distribution System:—		
Contracts completed and final payments made prior to January 1, 1905, . . . .	-	\$4,382,372 31
Warren Foundry and Machine Co., cast- iron water pipes and special castings, <sup>1</sup> . .	\$2,122 33	2,122 33
R. D. Wood & Co., special castings, . . .	1,857 28	1,857 28
	3,979 61	\$4,387,351 92
Deduct value of pipes, valves, etc., included in above list, transferred to maintenance account December 31, 1900, . . . .	-	3,139 77
		4,384,212 15
Additional work:—		
Labor, . . . . .	\$19,385 75	\$653,789 83
Professional services, medical services, anal- yses, etc., . . . . .	190 02	1,799 01
Travelling, . . . . .	437 25	2,427 22
Rent, . . . . .	-	3,556 73
Water rates, . . . . .	19 39	1,440 47
Freight and express, . . . . .	258 94	12,097 65
Jobbing and repairing, . . . . .	962 02	9,414 96
Tools, machinery, appliances and hardware supplies, . . . . .	856 48	72,239 42
Electrical supplies, . . . . .	94 47	4,924 68
Castings, ironwork and metals, . . . .	6,704 43	67,819 73
Iron pipe and valves, . . . . .	1,622 06	55,937 11
<i>Amounts carried forward,</i> . . . .	\$30,530 81	\$478,759 65
		\$885,446 81
		\$17,518,332 34

<sup>1</sup> Includes some ironwork for Wachusett Dam.

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1905.		From Beginning of Work to December 31, 1905.	
<i>Amounts brought forward,</i> . . .	\$30,530 81	\$478,759 65	\$885,446 81	\$17,518,332 34
<i>Construction — Con.</i>				
Additional work — <i>Con.</i>				
Blasting supplies, . . . . .	-		1,339 48	
Paint and coating, . . . . .	133 33		4,198 93	
Fuel, oil and waste, . . . . .	43 72		10,333 09	
Lumber and field buildings, . . . . .	1,794 82		81,749 40	
Drain pipe, . . . . .	224 80		8,924 28	
Brick, cement and stone, . . . . .	279 45		24,003 81	
Sand, gravel and filling, . . . . .	916 30		6,753 56	
Municipal and corporation work, . . . . .	510 28		208,166 67	
Police service, . . . . .	7,457 91		210,296 74	
Sanitary inspection, . . . . .	1,204 07		12,526 25	
Judgments and settlements for damages, . . . . .	5,188 45		42,483 06	
Unclassified supplies, . . . . .	900 70		15,303 36	
Miscellaneous expenses, . . . . .	47 55		3,085 83	
		49,232 19		1,514,661 27
Legal and expert:—				
Legal services, . . . . .	-		\$4,668 82	
Expert services, . . . . .	\$1,339 92		1,862 66	
Court expenses, . . . . .	-		909 04	
Miscellaneous expenses, . . . . .	122 00		171 05	
		1,461 92		7,611 57
<i>Real Estate.</i>				
Legal and expert:—				
Legal services, . . . . .	-		\$4,736 31	
Conveyancer and assistants, . . . . .	\$4,731 00		104,119 97	
Experts, . . . . .	-		17,371 58	
Appraisers, . . . . .	912 27		21,961 36	
Court expenses, . . . . .	1,394 50		9,823 30	
Counsel expenses, . . . . .	-		43 25	
Conveyancing supplies, . . . . .	6 00		3,155 53	
Conveyancing expenses, . . . . .	76 36		5,794 34	
Miscellaneous expenses, . . . . .	267 69		4,195 81	
Settlements made by Board, . . . . .	30,755 00		3,290,070 84	
Judgments, . . . . .	22,170 35		159,100 58	
Taxes and tax equivalents, . . . . .	265 34		68,182 41	
Care and disposal, . . . . .	7,199 16		74,612 13	
		67,777 67		3,763,867 41
<i>Damages to Real Estate not taken, to Business and on Account of Loss of Wages.</i>				
Legal and expert:—				
Legal services, . . . . .	-		\$1,130 67	
Expert services, . . . . .	-		1,635 08	
Court expenses, . . . . .	\$1,330 70		11,570 29	
Settlements, . . . . .	16,760 00		397,627 82	
Judgments, . . . . .	7,941 08		96,639 68	
		26,031 78		508,603 54
<i>Amounts carried forward,</i> . . . . .		\$623,263 21		\$23,312,876 13



GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1905.	From Beginning of Work to December 31, 1905.
<i>Amounts brought forward,</i> . . . . .	\$623,263 21	\$23,312,876 13
<i>Claims on Account of Diversion of Water.</i>		
Legal and expert :—		
Legal services, . . . . .	-	\$3,774 98
Expert services, . . . . .	-	19,339 69
Court expenses, . . . . .	-	19,105 69
Miscellaneous expenses, . . . . .	-	1,222 63
Settlements, . . . . .	-	917,350 00
Judgments, . . . . .	-	218,358 91
		1,179,151 90
<i>Purchase of Existing Water Works.</i>		
Legal and expert :—		
Legal services, . . . . .	-	\$1,878 89
Expert services, . . . . .	\$9,200 21	13,569 82
Court expenses, . . . . .	23,495 05	27,228 38
Miscellaneous expenses, . . . . .	-	1,470 94
Settlements and judgments, . . . . .		14,330,440 78
	32,695 26	14,374,588 81
<i>Relocation Central Massachusetts Railroad.</i>		
Settlements, . . . . .	-	177,597 39
Total amount of construction expenditures, . . . . .	\$655,958 47	\$39,044,214 23

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1905.
<b>MAINTENANCE AND OPERATION OF WORKS.</b>	
Administration :—	
Commissioners, . . . . .	\$3,500 00
Secretary, auditor and assistants, . . . . .	4,672 67
Postage, printing, stationery and other supplies, . . . . .	1,626 57
Travelling, . . . . .	94 64
Telephone, heating, lighting and care of building, . . . . .	549 09
Alterations and repairs of building, . . . . .	103 44
Rent and taxes, office building, . . . . .	420 00
Miscellaneous expenses, . . . . .	39 50
	\$11,005 91
Supervision and general superintendence :—	
Chief engineer and department engineers, . . . . .	\$8,150 01
Engineering and clerical assistants, . . . . .	7,848 90
Postage, printing, stationery and office supplies, . . . . .	715 51
Telephone, heating, lighting and care of offices, . . . . .	1,912 90
Travelling and incidental expenses, . . . . .	165 20
Alterations and repairs of buildings, . . . . .	546 48
Rent and taxes, main office, . . . . .	1,260 00
Miscellaneous expenses, . . . . .	205 70
	20,804 70
<i>Amount carried forward,</i> . . . . .	\$31,810 61

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1905.
<i>Amount brought forward,</i> . . . . .	. . . \$31,810 61
Pumping service :—	
Labor, . . . . .	\$45,848 36
Fuel, . . . . .	39,154 23
Oil, waste and packing, . . . . .	1,571 69
Repairs and renewals, . . . . .	3,431 85
Small supplies and expenses, . . . . .	2,627 08
Rent, West Roxbury pumping station, . . . . .	771 24
	93,404 45
Superintendents and assistant superintendents, . . . . .	\$3,827 44
Engineering assistants, . . . . .	13,017 20
Laboratory force, . . . . .	2,189 93
Sanitary inspectors, . . . . .	3,473 52
Recording and scientific instruments and supplies, . . . . .	662 73
Labor and teaming, . . . . .	107,733 84
Tools, machinery and appliances, . . . . .	2,842 18
Lumber and hardware supplies, . . . . .	3,872 63
Jobbing and repairing, . . . . .	821 01
Travelling, . . . . .	4,525 84
Horses, vehicles and stable expenses, . . . . .	4,178 09
Fuel, lighting and telephone, . . . . .	5,515 94
Municipal and corporation work, . . . . .	499 24
Unclassified supplies, . . . . .	6,208 87
Miscellaneous expenses, . . . . .	3,568 23
Conveyancer and assistants, . . . . .	1 60
Taxes and tax equivalents, . . . . .	29,896 13
Contracts and agreements, . . . . .	446 50
Contracts for pipes, valves, etc., bought from construction work since January 1, 1905, . . . . .	181 59
	193,462 51
Total expenditures for maintenance and operation, . . . . .	\$318,677 57

(b) *Receipts.*

The total amount of receipts from rents, sales of property, etc., for the year beginning January 1, 1905, and ending December 31, 1905, is \$69,567.52; and the total amount from the time of the organization of the Metropolitan Water Board, July 19, 1895, to December 31, 1905, is \$462,220.36. The general character of these receipts is as follows :—

GENERAL CHARACTER OF RECEIPTS.	For the Year ending December 31, 1905.	From Beginning of Work to December 31, 1905.
For distribution back to District:—		
District entrance fees, . . . . .	-	\$92,265 00
Supplying water outside of District, . .	\$33,222 75	84,879 59
Water furnished to water companies, . .	441 85	37,145 88
	\$33,664 60	\$214,290 47
To the credit of the loan fund:—		
Real estate and buildings, . . . . .	\$8,066 17	\$27,652 65
Labor, tools, supplies and reimbursements,	20,128 48	96,112 85
	28,194 65	123,765 50
To the credit of the sinking fund:—		
Forfeiture for contracts awarded but not executed, . . . . .	-	\$500 00
Rents, . . . . .	\$4,202 98	86,146 13
Land products, . . . . .	3,489 07	35,185 44
Unclassified receipts and interest, . .	16 22	2,332 82
	7,708 27	124,164 39
Total receipts, . . . . .	\$69,567 52	\$462,220 36

The foregoing receipts have been credited to the various objects or works, as follows:—

RECEIPTS FROM DIFFERENT WORKS.	For the Year ending December 31, 1905.	From Beginning of Work to December 31, 1905.
Distribution back to District:—		
Admission into Metropolitan Water District (Quincy, Nahant, Arlington, Stoneham, Milton and Lexington), . . . . .	-	\$92,265 00
Supplying water to cities and towns outside of Water District (Swampscott, Revere, Lexington and Cambridge), . . . .	\$33,222 75	84,879 59
Water furnished to water companies, . .	441 85	37,145 88
	\$33,664 60	\$214,290 47
Construction and acquisition of works:—		
Administration, . . . . .	\$29 00	\$42 15
Wachusett Dam, . . . . .	3 22	4,900 31
Wachusett Reservoir, . . . . .	16,899 60	121,037 85
Wachusett Aqueduct, . . . . .	-	5,204 70
Weston Aqueduct, . . . . .	433 73	4,747 47
Sudbury Reservoir and watershed, . .	2 50	7,277 26
Distribution system, . . . . .	7,052 68	61,754 42
Diversion of water, Clinton sewerage system,	86 85	1,277 94
Purchase of existing water works, . .	1,979 25	10,570 27
	26,486 83	216,812 37
Maintenance and operation of works:—		
Wachusett Aqueduct, . . . . .	\$409 75	\$3,470 36
Wachusett Reservoir, . . . . .	4,987 62	10,298 29
Sudbury system, . . . . .	640 38	7,497 31
Distribution system, . . . . .	2,894 67	7,174 45
Clinton sewerage system, . . . . .	483 67	2,677 11
	9,416 09	31,117 52
Total receipts, . . . . .	\$69,567 52	\$462,220 36



(c) *Assets.*

The following is an abstract of the assets of the Water Works, a complete schedule of which is kept on file in the office of the Board : —

Office furniture, fixtures and supplies ; engineering and scientific instruments and supplies ; police supplies ; horses, vehicles, field machinery, etc. ; machinery, tools and other appliances and supplies ; real estate connected with works not completed ; completed works, including real estate and buildings connected therewith.

(d) *Liabilities.*

There are liabilities as follows : —

Current bills unpaid, . . . . .	\$11,985 88 <sup>1</sup>
Due on monthly pay rolls, . . . . .	3,341 09
	<hr/>
	\$15,326 97

*Amounts reserved on Monthly Estimates, not due until Completion of Contracts or until Claims are settled.*

NAME.	Work.	Amount.
McArthur Bros. Co., . . . . .	Wachusett Dam, . . . . .	\$10,000 00
Busch Bros., . . . . .	Building road, Wachusett Reservoir, . . . . .	600 00
The H. Gore Co., . . . . .	Surfacing highways, Sect. 1, . . . . .	1,104 23
The H. Gore Co., . . . . .	Surfacing highways, Sect. 2, . . . . .	1,386 83
Bruno, Salomone & Petitti, . . . . .	Wachusett Reservoir, Sect. 10, . . . . .	25,000 00
John F. Magee & Co., . . . . .	South Dike, . . . . .	1,455 52
F. A. McCauliff, . . . . .	Masonry arch bridge at West Boylston, . . . . .	1,982 31
McArthur Bros. Co., . . . . .	Relocation Central Massachusetts Railroad, Sect. 2, . . . . .	10,000 00
		<hr/>
		\$51,528 89

Amounts have been agreed upon in the following cases, but the deeds have not yet passed : —

Martha E. Prescott, estate of, \$400 ; Bertram A. Bancroft, \$150 ; Lucy White, \$250 ; Pratt and Inman, \$48 ; Charles F. C. Henderson, \$800.

On the claims of the following it is impossible to state the amounts due for land damages, water rights and claims for damages to established business, as no sums have been agreed upon, and suits are now pending in the court for the determination of most of them : —

<sup>1</sup> Miscellaneous current bills of 1905, including those coming in from time to time, after January 1, 1906, have since been paid.

Charles L. Johnson, Charles B. Sawin, Framingham Water Company, Town of West Boylston, Eliza M. Childs *et al.*, Charles J. Paine, George H. Thompson, Benjamin H. Clemmons, Edward Dooley, Walter E. Chapman, Chapman and Tobin, Lucy Cutting, George D. Lawrence, Charles C. Landy, Alfred N. Whiting, Houghton Bros., Robert Johnson, George H. Longley, John F. O'Brien, Patrick Bradley, Thomas H. Burgess, Margaret F. Tonry, Lucy A. Wood, Edwin C. Fairbanks, Hannah McAndrew, Fred Counter, Whitman M. Huntington, George W. Brown, Clarence Carvill, estate of Andrew L. Fitch, Joseph O. Bullard *et al.*, Josiah W. Walkup, Mary Morse, William M. Bruce, Kayajan Serabian, Elwin I. Chase, Alzina A. Wilson, Henry F. Keyes, Robert C. Houghton *et al.*, John Burns, Patrick Daley, Rebecca T. Farr, Annie L. Gibbons, Francis Gibbons, John Gibbons, Henry Wilson Co-operative Bank, Mary J. Hensby, William E. Keating, Millard E. Lewis, Middlesex Fells Spring Company, Lillian F. Pullen *et al.*, William E. Sprague, James E. Welch, Caroline E. Tyson, Andrew Lienhardt, John E. Stone, Bridget M. Joyce, Israel L. Barnes, *et al.*, William L. Bancroft, George H. Chase, Andrew L. Nourse, Byron D. Allen, J. Frank Wood *et al.*, Harriet A. Adams, George F. Bond, Emory W. Johnson, Nellie M. Kirby, Elizabeth M. Myers, Emily S. Warren, Jennie L. Goodnow, Asa Knight, John Lambert, Emily W. Parker, Andrew J. Scarlett *et al.*, estate of Walter H. Smith, Worcester County Truant School, James H. Atherton, J. Quincy Dix, John E. Farnsworth, Mary J. Fyfe, estate of William E. Fyfe, Lizzie M. Gray, William B. Haskell, Henry F. Haynes, Sarah G. Haynes, Eben C. Mann, George M. Plummer, Howard D. Stone, Luther Willard, Bernard Adler, heirs of Anton Brinkhaus, estate of Bernard Brockelman, Margaret Graichen, Christopher Gunderman, Addie K. Harris, John A. Heinold, Joseph Maehnert, James Mulgren, William A. Nye, Frederick R. Peinert, Henry Richter, Jr., William H. Wilbur, Elizabeth Wittig, Susan C. Wright, Eva R. Zeigler, Bridget Zink, estate of Abigail Boynton, Lawrence Cavanaugh, Waldo B. Howe, Jonathan M. Keyes, William W. Keyes, Samuel F. Mason, Edward F. Merriam, James Roach, Henrietta M. Andrews, James A. Bigelow, First Parish of Boylston, William H. Brigham, John Fitzgerald, estate of Augustus Flagg, Mary J. Hastings, executrix, George R. Hastings, William H. Hastings, Henry J. Hyde, Everett and Oliver S. Kendall, Sanford

C. Kendall, William C. Rosenthal, Jennie W. Taylor, administratrix, estate of William H. Vickery, James H. and Hannah S. Wood, Asenath M. Bartlett, estate of Charles I. Longley, estate of Daniel M. Marsh, Harthan and Wilder, Henry B. Stone, Joseph M. Bigelow, Louis Bond, Francis W. M. Goodale, Henry L. Hastings, Waldo B. Howe, Per Arvid Lundgren, James Moran, John B. F. Prescott, John V. Tobin, administrator, Mary J. Warren, Ashley H. Wood, Charles H. and Lizzie M. Chandler, John Dee, Silas E. Harthan, John Lynch, heirs of Maurice Mulcahy, estate of Mary C. Rice, Mary Scanlon *et al.*, Eclid Sene, Waushacum Lake Company, John S. Ott, Annie Coans *et al.*, Catherine Flanagan, Lawrence Fury, Bridget Harrity *et al.*, Catherine Kittredge, Catherine J. Kittredge, Patrick A. and Bridget Kittredge, Patrick H. Morrison, Helen Nickerson *et al.*, James E. Wise, Edward J. DeCoursey.

## VI. METROPOLITAN SEWERAGE WORKS.

The Metropolitan Sewerage Works are divided into two systems, the North Metropolitan System and the South Metropolitan System.

The North Metropolitan System provides for the district situated largely in the Charles River and Mystic River valleys lying north of the Charles River, and embraces the cities of Cambridge, Chelsea, Everett, Malden, Medford, Melrose, Somerville, Woburn and parts of Boston, and the towns of Arlington, Belmont, Revere, Stoneham, Wakefield, Winchester, Winthrop and part of Lexington. The district has an area of 90.50 square miles. It has an estimated population, as of December 31, 1905, based upon the census of 1905, of 478,845; and it is estimated that of this number 376,575, or 78.6 per cent., contribute sewage to the North Metropolitan System.

The South Metropolitan System provides for the areas situated in the Charles River valley lying south of the Charles River, a portion of the valley north of the Charles River, and also a portion of the Neponset River valley, and embraces the cities of Newton, Quincy, Waltham and portions of Boston, and the towns of Brookline, Hyde Park, Milton, Watertown and part of Dedham. This district has an area of 100.87 square miles. It has an estimated population, as of December 31, 1905, of 300,650, of which number it is estimated that 156,360, or 52 per cent., contribute sewage to the South Metropolitan System.



### (1) NORTH METROPOLITAN SYSTEM — CONSTRUCTION.

During the past year no actual construction has been carried on for the North Metropolitan System, although certain bills contracted during the preceding year, amounting to \$2,260.65, were paid during the year 1905 on account of construction.

### (2) SOUTH METROPOLITAN SYSTEM — CONSTRUCTION.

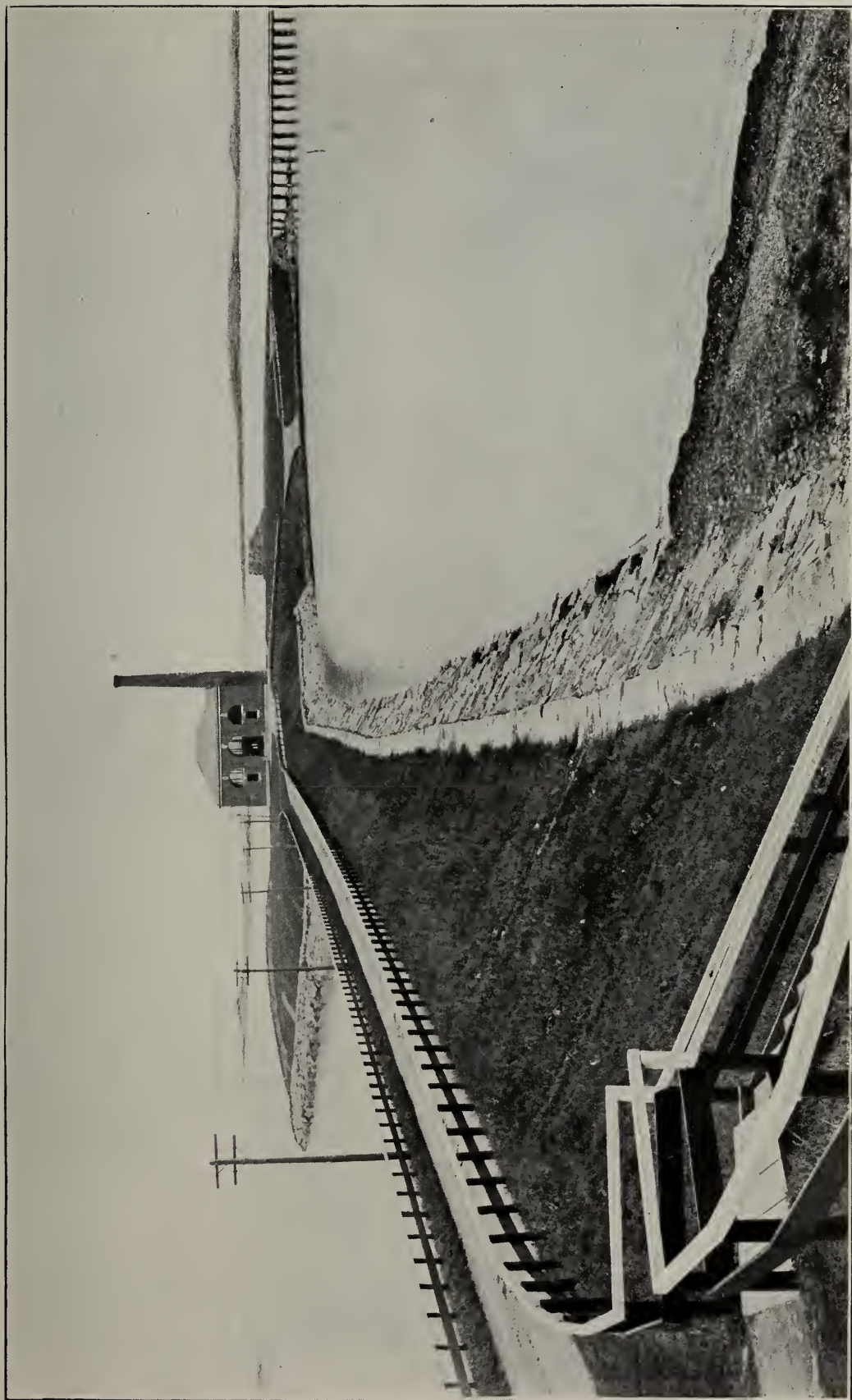
The construction carried on during the past year in the South Metropolitan District has been for the completion of the High-level Sewer, which had been in process of building for several years preceding.

The grounds at Nut Island have been graded in such manner as to give the island a natural appearance similar to that which it formerly had, and the slopes have been covered with loam. Roads have been constructed upon the island and across the bar or embankment connecting the island with the main land at Hough's Neck.

Proper roadways and paths have also been constructed at the Ward Street station, and the surrounding grounds have been graded, covered with loam and seeded.

A 24-inch cast-iron force main has been laid from its connection with the High-level Sewer at Greenleaf Street in Quincy to the Quincy pumping station, a total length of 3,025 feet. The line was laid to a considerable extent through Merrymount Park, but the work was accomplished without injury to the shrubbery or trees of the park. The main was completed in August, and on August 14 the Quincy sewage was diverted from the Moon Island works of the city of Boston and has since been discharged through the High-level Sewer.

When the Charles River valley sewer was diverted at Vancouver Street so as to connect with the Ward Street station and the High-level Sewer, there was left, extending from Vancouver Street along Huntington Avenue to Gainsborough Street and connecting with the Boston Main Drainage Works, a length of about 1,800 feet. In order that this portion of the South Metropolitan District should contribute its sewage to the High-level Sewer, it was necessary to change the grade of the sewer so as to cause the sewage to run in the opposite direction. The territory in question remained tributary to the Boston Main Drainage Works during a large part of the year,



HIGH-LEVEL SEWER--NUT ISLAND WITH SCREEN HOUSE AND EMBANKMENT CONNECTING IT WITH GREAT HILL.





pending a discussion with the city of Boston in relation to an interchange of sewers for mutual benefit; but in December it was deemed advisable to proceed with the work of making the change, which is still in progress. About 1,100 feet, extending from Vancouver Street to Parker Street, have been nearly completed. It is expected that the change will be entirely accomplished on or about March 1 of the current year, at which time the entire flow of the old Charles River valley main sewer will be carried to the Ward Street station and discharged through the High-level Sewer.

Upon the completion of the above-mentioned work all the sewage of the South Metropolitan System will be delivered into the High-level Sewer for disposal at the outlets off Nut Island, with the exception of the sewage of small districts in Dorchester and Milton, included in the Neponset River valley system. The areas of these districts are too low for sewage to be delivered into the High-level Sewer without pumping, and arrangements for the disposal of the sewage from these sections through the Boston Main Drainage Works will continue to be made with the city of Boston.

All the foregoing work of construction upon the South Metropolitan System has been carried on by day labor under the immediate direction of the engineers and foremen of the maintenance department.

The two Allis engines in the Ward Street pumping station have been in regular operation for more than a year past, but from time to time various modifications and changes have been made, as found essential to satisfy the rigorous tests under the contract for their construction. The trial tests of these engines have therefore not yet been made, and the final payments under the contract have yet to be adjusted.

### (3) SETTLEMENTS FOR REAL ESTATE.

Since January 1, 1905, settlements have been effected on account of the takings made in the North Metropolitan District in 2 cases, involving a payment of \$575; and in cases in the South Metropolitan District 6 settlements have been effected, under which payments have been made amounting to \$2,178.62.

Of the 8 sewerage settlements, 4 were on account of the sewer extension to Brookline, 2 on account of the extension of the sewer in Cambridge for Belmont, 2 on account of the High-level Sewer, 1 in Quincy and 1 in Milton.

Summary of Land Settlements for the Year 1905.

LOCATION.	Area in Acres.	Number of Settlements.	Payments.
<i>North Metropolitan District.</i>			
Cambridge, . . . . .	.087	2	\$575 00
Total, . . . . .	.087	2	\$575 00
<i>South Metropolitan District.</i>			
Milton, . . . . .	.741	1	\$380 08
Newton, . . . . .	1.070	4	1,473 54
Quincy, . . . . .	.364	1	325 00
Total, . . . . .	2.175	6	\$2,178 62
Aggregate, . . . . .	2.262	8	\$2,753 62

(4) NORTH METROPOLITAN SYSTEM — MAINTENANCE.

The North Metropolitan System required the maintenance of 58.004 miles of main sewers, with which are connected 573.57 miles of local sewers, the number of connections with the Metropolitan System being 583.

Of the municipalities belonging to this system, the Deer Island district of Boston, Winthrop, Malden, Melrose, Medford, Winchester, Woburn, Stoneham, Arlington, Belmont, Wakefield and Revere maintain separate sewers, the East Boston and Charlestown districts of Boston, Everett, Cambridge, Somerville and Chelsea have both separate and combined sewers.

Four pumping stations are maintained for this system, the Alewife Brook pumping station at Somerville, the East Boston pumping station, the Charlestown pumping station and the Deer Island pumping station.

There have been pumped at the Alewife Brook pumping station 3,234,000 gallons of sewage per day, with an average lift of 13.13 feet, at a cost of \$0.340 per million gallons per foot lifted; at the Charlestown station 29,900,000 gallons per day, 7.85 feet lift, at a cost of \$0.154 per million gallons per foot; at the East Boston station 52,400,000 gallons per day, 16.23 feet lift, at a cost of \$0.060 per million gallons per foot; and at the Deer Island station 54,400,000 gallons per day, 10.63 feet lift, at a cost of \$0.087 per

million gallons per foot lifted. The cost of pumping per million gallons has been considerably reduced from the cost in the preceding years. The number of gallons of sewage discharged at the outfall in Boston harbor is represented by the number of gallons of sewage pumped at the Deer Island station. Owing to the unusually dry season, the amounts pumped showed a decrease from the preceding year varying at the different stations from 3.9 per cent. to 8.8 per cent.

Taking the estimated population of the district contributing sewage, the amount of sewage discharged averaged 144 gallons per day for each person; but this amount represents a considerable quantity of rain water received in the sewers, as not all of the local sewers were restricted to the admission of sewage proper only.

During the year 12 public and 26 special connections with local sewers have been made, giving a total addition of 48.81 miles of connecting sewers.

It was found that the action of the sea had caused the removal of a portion of the embankment placed over the outfall sewer running from Deer Island, and consequently a considerable amount of riprap has been deposited upon the embankment in order to prevent further encroachment.

The new main sewer, built in the years 1900 and 1901 to receive the sewage of the town of Wakefield, was extended only to a point in the city of Malden near Barrett's Pond, where it was connected with the original Metropolitan main sewer, it being deemed that for a series of years the original sewer had a sufficient capacity from this point to discharge the contents of both sewers. During the past year the Metropolitan sewer below Barrett's Pond became at times surcharged, and considerable overflows of sewage resulted. It is now necessary to continue the Wakefield sewer to tide water, and authorization therefor, at an estimated cost of \$55,000, has been sought from the Legislature.

The cost of maintenance of the North Metropolitan System during the past year was \$117,517.07.

#### (5) SOUTH METROPOLITAN SYSTEM — MAINTENANCE.

In the South Metropolitan System there are maintained 38.121 miles of main sewers, with which are connected 439.74 miles of local sewers, having 100 connections with the Metropolitan System.



Newton, Watertown, Waltham, Hyde Park, Dedham, the West Roxbury district of Boston and Quincy maintain separate sewers, and the Back Bay, Brighton and Dorchester districts of Boston, Brookline and Milton maintain both separate and combined sewers.

There are maintained for this system the Ward Street pumping station, the Quincy pumping station and the screen-house at Nut Island.

The Ward Street pumping station, which was first put into operation near the end of the preceding year, has since been in constant service. The pumping engines, though put to regular use, have been subject to tests and modifications by the contractors prior to their final test for acceptance, which has not yet been made.

There have been pumped at the Ward Street station an average of 20,940,000 gallons per day, with an average lift of 40.26 feet, at a cost of \$0.066 per million gallons per foot lifted; and at the Quincy station 3,180,000 gallons, 32.18 feet lift, at an average cost of \$0.17 per million gallons per foot lifted.

An average of 25,000,000 gallons of sewage has passed daily through the screens at the Nut Island screen-house, and been discharged from the outfalls into the outer harbor. The maximum discharge per day has been 78,000,000 gallons, which occurred during a heavy storm. The sewage discharged averages 160 gallons per day per person of the estimated number contributing sewage in the district.

An examination by divers of the bed of the harbor near the outlets has failed to reveal deposits of any kind, and, upon careful investigations of the shores of both mainland and islands in the vicinity, few if any traces of sewer deposits have been found.

The sewage required to be pumped by the Quincy station has reached the proper capacity of the present engines. The flow received during periods of storms already exceeds the capacity of the larger of the two pumping engines, so that serious consequences might ensue from the breaking down of either of them. The Board has accordingly determined to supply an additional engine for this station.

The expenditures for maintenance for the past year were \$146,076.06.

It is expected that, inasmuch as early in the current year the sewage of the Huntington Avenue section of the Charles River valley

district in Boston will be received into the High-level Sewer, thereafter no rental will be payable to the city of Boston on account of the discharge, through the Boston Main Drainage Works, of sewage of the South Metropolitan District, except that coming from the comparatively small low area in Dorchester and Milton.

#### VII. SEWERAGE WORKS—FINANCIAL STATEMENT.

The Metropolitan sewerage loans for the construction of the Sewerage Works of the North Metropolitan System have amounted to \$6,105,865.73, to which are added receipts from various sources amounting to \$17,153.40. The amount of expenditures approved by the Board for payment for the year 1905 was \$2,260.65, and the total amount of expenditures approved to January 1, 1906, was \$6,088,830.56. The balance on hand January 1, 1906, was \$34,188.57.

The loans for the construction of the various parts of the South Metropolitan System have amounted to \$7,692,046.27. The receipts applicable to the loan fund have been \$6,622.27. The amount of expenditures approved for payment in the year 1905 was \$43,780.19. The total amount of expenditures approved for payment from the beginning of the works has been \$7,624,042.66. The balance on hand for the South Metropolitan System on January 1, 1906, was \$74,625.88.

The bonds issued on account of the loans have been for varying periods, not exceeding forty years, and bear interest at the rate of 3 per cent. and  $3\frac{1}{2}$  per cent. The premiums received on account of the sale of bonds on the North Metropolitan System have amounted to \$173,819.15, and those received on account of the South Metropolitan System have amounted to \$389,374.53.

The amount expended for maintenance of the North Metropolitan System in the year 1905 was \$117,517.07, and for the South Metropolitan System \$146,076.06, a total for both systems of \$263,593.13.

The assessments made to meet interest, sinking fund requirements, and maintenance and operation of the North Metropolitan System amounted in the year 1905 to \$378,507.29, and the assessments for the South Metropolitan System amounted to \$441,566.78.

The following is a detailed financial statement regarding the Metropolitan Sewerage Works:—

## (1) METROPOLITAN SEWERAGE LOANS, RECEIPTS AND PAYMENTS.

The loans for the construction of the Metropolitan Sewerage Works, the receipts which are added to the proceeds of these loans, and the expenditures for construction have been as follows :—

*(a) North Metropolitan System.*

Loans under various acts of the Legislature (given in detail in report for the year 1901), . . . . .	\$5,605,865 73
Loans under chapters 242, 336 and 399, Acts of 1903, . . . . .	500,000 00
Proceeds from sales of property and from other sources to December 31, 1905, . . . . .	17,153 40
	<hr/>
	\$6,123,019 13
Amount approved by the Metropolitan Sewerage Commission and the Metropolitan Water and Sewerage Board for payment to December 31, 1905 (of which \$2,260.65 is for the year 1905), . .	6,088,830 56
	<hr/>
Balance, North Metropolitan System, January 1, 1906, . . . .	\$34,188 57

*(b) South Metropolitan System.**Charles River Valley Sewer.*

Loans under the Acts of the years 1889 and 1900, . . . . .	-	\$800,046 27
Amount approved by the Metropolitan Sewerage Commission for payment to December 31, 1905, . . . . .	\$800,046 27	

*Neponset River Valley Sewer.*

Loans under various acts of the Legislature (given in detail in report for the year 1901), . . . . .	-	900,000 00
Loan, chapter 315, Acts of 1903, . . . . .	-	4,000 00
Proceeds from pumping ground water, . . . . .	-	109 50
Amount approved by the Metropolitan Sewerage Commission and the Metropolitan Water and Sewerage Board for payment to December 31, 1905 (of which \$2,269.54 is for the year 1905), . . . . .	905,733 80	

*High-level Sewer.*

Loan under chapter 424 of the Acts of 1899, original loan, . . . . .	-	4,600,000 00
Loan, chapter 356 of the Acts of 1903, . . . . .	-	996,000 00
Loans, chapters 230 and 246 of the Acts of 1904, . . . . .	-	392,000 00
Proceeds from sales of property and other sources to December 31, 1905 (of which \$644.28 is for the year 1905), . . . . .	-	6,512 77

*Amounts carried forward, . . . . .* \$1,705,780 07 \$7,698,668 54



*Amounts brought forward,* . . . . . \$1,705,780 07 \$7,698,668 54

Amount approved by the Metropolitan Sewerage  
Commission and the Metropolitan Water and  
Sewerage Board for payment to December 31, 1905  
(of which \$41,510.65 is for the year 1905), . . . 5,918,262 59  
7,624,042 66

Balance, South Metropolitan System, January 1,  
1906, . . . . . \$74,625 88

(2) ISSUES OF METROPOLITAN SEWERAGE LOAN BONDS.

The Treasurer of the Commonwealth, under the authority of the  
successive statutes, has from time to time issued bonds designated  
“Metropolitan Sewerage Loan,” as follows : —

METROPOLITAN SEWER LOANS, NORTH SYSTEM.  
*Bonds issued.*

DATE OF SALE.	Amount of Bonds sold.	Rate of In- terest (per cent.).	Price received.	Date due.	Premium.
Apr. 2, 1890, . . . . .	\$500,000	3	102.40	Jan. 1, 1930,	\$12,000 00
Apr. 2, 1890, . . . . .	500,000	3	103.02	Jan. 1, 1930,	15,100 00
Apr. 2, 1890, . . . . .	500,000	3	103.62	Jan. 1, 1930,	18,100 00
Apr. 2, 1890, . . . . .	500,000	3	102.327	Jan. 1, 1930,	11,635 00
Apr., 1890, . . . . .	200,000	3	103.	Jan. 1, 1930,	6,000 00
Feb., 1891, . . . . .	50,000	3	104.	Jan. 1, 1930,	} 35,130 30 <sup>1</sup>
Mar., 1891, . . . . .	300,000	3	104.	Jan. 1, 1930,	
Mar., 1891, . . . . .	18,000	3	104.	Jan. 1, 1930,	
Jan., 1892, . . . . .	35,000	3	100.	Jan. 1, 1930,	-
Feb., 1892, . . . . .	29,000	3	100.	Jan. 1, 1930,	-
Mar., 1892, . . . . .	50,000	3	101.	Jan. 1, 1930,	500 00
June, 1892, . . . . .	436,000	3	101.50	Jan. 1, 1930,	} 11,060 00 <sup>1</sup>
July, 1892, . . . . .	150,000	3	101.50	Jan. 1, 1930,	
Aug., 1892, . . . . .	150,000	3	101.50	Jan. 1, 1930,	
Nov., 1892, . . . . .	3,000	3	100.50	Jan. 1, 1930,	15 00
Nov., 1892, . . . . .	200,000	3	100.	Jan. 1, 1930,	-
Jan., 1893, . . . . .	35,000	3	100.50	Jan. 1, 1930,	175 00
Jan., 1893, . . . . .	25,000	3	100.50	Jan. 1, 1930,	125 00
Feb., 1893, . . . . .	20,000	3	101.	Jan. 1, 1930,	200 00
Feb., 1893, . . . . .	5,000	3	100.50	Jan. 1, 1930,	25 00
Feb., 1893, . . . . .	400,000	3	100.25	Jan. 1, 1930,	1,000 00
Mar., 1893, . . . . .	94,000	3	100.25	Jan. 1, 1930,	235 00
May 1, 1894, . . . . .	464,000	3	100.	Jan. 1, 1930,	-
Oct., 1894, . . . . .	4,000	3	100.	Jan. 1, 1930,	-
Oct., 1894, . . . . .	1,000	3	100.	Jan. 1, 1930,	-
Nov., 1894, . . . . .	15,000	3	100.	Jan. 1, 1930,	-
Nov., 1894, . . . . .	10,000	3	100.	Jan. 1, 1930,	-
Dec., 1894, . . . . .	6,000	3	100.	Jan. 1, 1930,	-
Apr., 1895, . . . . .	300,000	3	100.	Jan. 1, 1930,	-
Dec., 1896, . . . . .	30,000	3	100.	Jan. 1, 1930,	-

<sup>1</sup> Readjustment of Treasurer.

METROPOLITAN SEWER LOANS, NORTH SYSTEM — *Concluded.**Bonds issued — Concluded.*

DATE OF SALE.	Amount of Bonds sold.	Rate of In- terest (per cent.).	Price received.	Date due.	Premium.
June, 1897, . . . . .	\$70,000	3½	106.243	Jan. 1, 1930,	\$5,084 80 <sup>1</sup>
June, 1897, . . . . .	10,000	3½	106.243	Jan. 1, 1930,	
Apr., 1898, . . . . .	5,000	3	100.	Jan. 1, 1930,	22,843 75 <sup>1</sup>
June, 1898, . . . . .	155,000	3½	100.	Jan. 1, 1930,	
June, 1898, . . . . .	60,000	3½	100.	Jan. 1, 1930,	
Apr., 1900, . . . . .	265,000	3	103.948	Jan. 1, 1930,	10,462 20
May, 1903, . . . . .	200,000	3½	104.9797	Jan. 1, 1930,	9,959 40
May, 1903, . . . . .	50,000	3½	106.2424	Jan. 1, 1943,	3,121 20
July, 1903, . . . . .	250,000	3½	104.419	July 1, 1943,	11,047 50
	\$6,095,000				\$173,819 15

## METROPOLITAN SEWER LOANS, SOUTH SYSTEM.

*Bonds issued.*

DATE OF SALE.	Amount of Bonds sold.	Rate of In- terest (per cent.).	Price received.	Date due.	Premium.
Apr., 1890, . . . . .	\$100,000	3	103.	Jan. 1, 1930,	\$3,000 00
Apr., 1890, . . . . .	400,000	3	103.	Jan. 1, 1930,	12,000 00
May, 1890, . . . . .	300,000	3	104.	Jan. 1, 1930,	12,000 00
Aug., 1895, . . . . .	300,000	3	100.565	Mar. 1, 1935,	1,755 00
Feb., 1896, . . . . .	50,000	3	100.	Mar. 1, 1935,	-
Dec., 1896, . . . . .	135,000	3	100.	Mar. 1, 1935,	-
Dec., 1896, . . . . .	15,000	3	100.	Mar. 1, 1935,	-
June, 1897, . . . . .	300,000	3½	106.98	Mar. 1, 1935,	20,940 00
June, 1898, . . . . .	35,000	3½	100.	Mar. 1, 1935,	4,088 00 <sup>1</sup>
June, 1899, . . . . .	25,000	3	100.64	Mar. 1, 1936,	160 00
June, 1899, . . . . .	1,000,000	3	100.64	July 1, 1939,	6,400 00
Sept., 1900, . . . . .	10,000	3	100.79	July 1, 1939,	79 00
Sept., 1900, . . . . .	912	3	100.	July 1, 1939,	-
Apr., 1901, . . . . .	40,000	3	100.915	Mar. 1, 1936,	366 00
Sept., 1901, . . . . .	2,000,000	3½	106.71	July 1, 1940,	134,200 00
Sept., 1902, . . . . .	14,000	3	100.	July 1, 1939,	-
Sept., 1902, . . . . .	500,000	3½	107.243	July 1, 1940,	36,215 00
Sept., 1902, . . . . .	150,000	3½	107.2395	July 1, 1940,	10,859 25
Dec., 1902, . . . . .	200,000	3½	107.79	July 1, 1940,	15,580 00
Feb., 1903, . . . . .	100,000	3½	108.25	July 1, 1940,	8,230 56 <sup>1</sup>
Apr., 1903, . . . . .	100,000	3½	106.75	July 1, 1940,	6,750 00
Apr., 1903, . . . . .	175,000	3½	106.75	July 1, 1940,	11,812 50
Apr., 1903, . . . . .	203,000	3½	106.75	July 1, 1940,	13,702 50
Apr., 1903, . . . . .	25,000	3½	106.494	July 1, 1940,	1,623 50
Apr., 1903, . . . . .	133,000	3½	105.9364	July 1, 1940,	7,895 42
May, 1903, . . . . .	996,000	3½	106.2424	Jan. 1, 1943,	62,174 31
May, 1903, . . . . .	4,000	3½	105.5453	Mar. 1, 1935,	221 81
July, 1904, . . . . .	392,000	3½	104.929	July 1, 1944,	19,321 68
	\$7,702,912				\$389,374 53

<sup>1</sup> Readjustment of Treasurer.

## (3) METROPOLITAN SEWERAGE LOANS SINKING FUND.

Under authority of chapter 122 of the Acts of 1899, and section 14 of chapter 424 of the Acts of 1899, the Treasurer of the Commonwealth was required to consolidate the sinking funds of all the Metropolitan sewerage loans into one fund, to be known as the Metropolitan Sewerage Loans Sinking Fund. The Board received, during the year, from rentals and from other sources, to be applied to the sinking fund, \$75.

The sinking fund established has amounted at the end of each year to sums as follows: —

December 31, 1899, . . . . .	\$361,416 59	December 31, 1903, . . . . .	\$754,690 41
December 31, 1900, . . . . .	454,520 57	December 31, 1904, . . . . .	878,557 12
December 31, 1901, . . . . .	545,668 26	December 31, 1905, . . . . .	1,008,724 95
December 31, 1902, . . . . .	636,084 04		

## (4) ANNUAL APPROPRIATIONS, RECEIPTS AND EXPENDITURES.

The annual appropriations for the maintenance of the Metropolitan Sewerage Works, the receipts of the Board which are added to the appropriations for maintenance, and the expenditures for maintenance for the year ending December 31, 1905, have been as follows: —

*North Metropolitan System.*

Balance January 1, 1905, . . . . .	\$21,593 22
Appropriation under chapter 215 of the Acts of 1905, . . . . .	127,000 00
Receipts from pumping and from other sources, . . . . .	1,821 00

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\$150,414 22

Amount approved by the Board for payment, . . . . .	117,517 07
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Balance January 1, 1906, . . . . .	\$32,897 15
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*South Metropolitan System.*

Balance January 1, 1905, . . . . .	\$410 48
Appropriation under chapter 214 of the Acts of 1905, . . . . .	144,920 00
Receipts from sales of property, from pumping and from other sources, . . . . .	885 57

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\$146,216 05

Amount approved by the Board for payment, . . . . .	146,076 06
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Balance January 1, 1906, . . . . .	\$139 99
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## (5) ANNUAL ASSESSMENTS.

Assessments for the year, amounting to \$378,507.29 for the North Metropolitan System and to \$441,566.78 for the South Metropolitan System, were required for the payment of interest and sinking fund requirements and the cost of maintenance and operation of works. The requirements for the North Metropolitan System were: for interest, \$195,409.32; for the sinking fund, \$51,807.19; and for maintenance, \$131,290.78. For the South Metropolitan System the requirements were: for interest, \$248,235.92; for the sinking fund, \$45,729.02; and for maintenance, \$147,601.84. These assessments were made upon the cities and towns in the respective districts in accordance with the ratios determined by the Apportionment Commissioners under chapter 439 of the Acts of the year 1889 and chapter 224 of the Acts of the year 1899, and were as follows: —

*North Metropolitan Sewerage System.*

Arlington, . . .	\$8,320 12	Somerville, . . .	\$51,853 10
Belmont, . . .	4,769 69	Stoneham, . . .	5,105 05
Boston, . . .	66,616 40	Wakefield, . . .	7,866 30
Cambridge, . . .	89,341 00	Winchester, . . .	7,944 84
Chelsea, . . .	25,166 15	Winthrop, . . .	6,159 96
Everett, . . .	18,889 74	Woburn, . . .	11,024 37
Lexington, . . .	2,549 18	Revere, . . .	12,693 48
Malden, . . .	29,709 46		
Medford, . . .	18,421 41	Total, . . .	\$378,507 29
Melrose, . . .	12,077 04		

*South Metropolitan Sewerage System.*

Boston, . . .	\$186,191 56	Quincy, . . .	\$28,586 71
Brookline, . . .	75,288 19	Waltham, . . .	27,997 80
Dedham, <sup>1</sup> . . .	11,115 08	Watertown, . . .	13,604 46
Hyde Park, . . .	15,347 41		
Milton, . . .	19,637 96	Total, . . .	\$441,566 78
Newton, . . .	63,797 61		

<sup>1</sup> Exclusive of Westwood.

## (6) EXPENDITURES FOR THE DIFFERENT WORKS.

The following is a summary of the expenditures made in the various operations for the different works: —

CONSTRUCTION.	For Year ending December 31, 1905.	From Beginning of Work to December 31, 1905.
<i>North Metropolitan System.</i>		
Original system, main line and branches, . . . . .	-	\$5,383,932 67
Lexington branch, . . . . .	-	68,585 15
Everett branch, . . . . .	-	54,877 12
Wakefield branch, . . . . .	-	35,698 29
Stoneham branch, . . . . .	-	11,574 10
Chelsea and Everett outlets, . . . . .	\$200 00	71,216 41
Wakefield branch extension, . . . . .	187 20	190,070 97
Revere extension, . . . . .	1,271 08	215,722 79
Belmont extension, . . . . .	602 37	57,153 06
Total North Metropolitan System, . . . . .	\$2,260 65	\$6,088,830 56
<i>South Metropolitan System.</i>		
Charles River valley sewer, main line, . . . . .	-	\$800,046 27
Neponset River valley sewer, main line, . . . . .	\$50 00	\$866,595 66
Brookline branch, . . . . .	2,219 54	39,138 14
High-level Sewer, . . . . .	41,510 65	905,733 80
Total South Metropolitan System, . . . . .	43,780 19	5,918,262 59
Total for construction, both systems, . . . . .	\$46,040 84	\$7,624,042 66
		\$13,712,873 22

MAINTENANCE.	For Year ending December 31, 1905.	From Beginning of Work to December 31, 1905.
North Metropolitan System, . . . . .	\$117,517 07	\$1,012,779 47
South Metropolitan System, . . . . .	146,076 06	936,356 33
Total for maintenance, both systems, . . . . .	\$263,593 13	\$1,949,135 80

## (7) DETAILED FINANCIAL STATEMENT.

The Board herewith presents, in accordance with the Metropolitan Sewerage Acts, an abstract of the expenditures and disbursements, receipts, assets and liabilities for the year ending December 31, 1905 : —

(a) *Expenditures and Disbursements.*

GENERAL CHARACTER OF EXPENDITURES.	For Year ending December 31, 1905.
<i>North Metropolitan System — Construction.</i>	
Engineers, inspectors, rodmen, laborers and others, . . . . .	\$22 00
Postage, telephone and telegrams, . . . . .	1 76
Brick, cement, lumber and other field supplies, . . . . .	796 12
Amount carried forward, . . . . .	\$819 88

GENERAL CHARACTER OF EXPENDITURES.	For Year ending December 31, 1905.
<i>Amount brought forward,</i> . . . . .	\$819 88
<i>North Metropolitan System — Construction — Concluded.</i>	
Contracts : —	
Chelsea and Everett Outlets : —	
H. A. Hanscom & Co., Sect. 56, . . . . .	200 00
Revere Extension : —	
Charles A. Haskin, Sect. 61, . . . . .	638 40
Land takings, purchase and recording, . . . . .	602 37
Total, . . . . .	\$2,260 65
<i>South Metropolitan System — Construction.</i>	
<i>Neponset River Valley Sewer : —</i>	
Experts and appraisers, . . . . .	\$50 00
Brookline branch : —	
Carriage hire, . . . . .	15 00
Experts and appraisers, . . . . .	675 00
Land takings, purchase and recording, . . . . .	1,529 54
Total, . . . . .	\$2,269 54
<i>High-level Sewer : —</i>	
Secretary, . . . . .	\$175 00
Clerical services, . . . . .	295 00
Engineers, inspectors, rodmen, laborers and others, . . . . .	15,139 48
Carriage hire and travelling expenses, . . . . .	141 00
Rent of office, Ashburton Place, . . . . .	333 33
Teaming and express, . . . . .	22 00
Brick, cement, lumber and other field supplies, . . . . .	6,267 85
Tools and repairs of same, . . . . .	13 45
Contracts : —	
Hiram W. Phillips, Sect. 43, . . . . .	9,705 23
Lockwood Manufacturing Co., Sect. 44, . . . . .	1,678 80
Woodbury & Leighton Co., Sect. 44, . . . . .	1,500 00
E. W. & J. J. Everson, Sect. 66, . . . . .	950 00
E. W. Everson & Co., Sect. 75 (part), . . . . .	1,000 00
Lockwood Manufacturing Co., Sect. 77, . . . . .	1,929 30
Land takings, purchase and recording, . . . . .	757 71
Experts and appraisers, . . . . .	225 00
Legal services, . . . . .	31 50
Claims and allowances on contracts, . . . . .	1,250 00
Water rates and connections, . . . . .	96 00
Total, . . . . .	\$41,510 65
<i>North Metropolitan System — Maintenance.</i>	
Administration : —	
Commissioners, secretary and assistants, . . . . .	\$5,058 34
Postage, printing, stationery and office supplies, . . . . .	650 86
Rent, telephone, heating, lighting and care of offices, . . . . .	1,571 08
Miscellaneous expenses, . . . . .	102 14
Amount carried forward, . . . . .	\$7,382 42



GENERAL CHARACTER OF EXPENDITURES.	For Year ending December 31, 1905.
<i>Amount brought forward,</i> . . . . .	\$7,382 42
<i>North Metropolitan System — Maintenance — Concluded.</i>	
General superintendence: —	
Engineer and assistants, . . . . .	10,529 23
Postage, printing, stationery and office supplies, . . . . .	993 99
Rent, telephone, heating, lighting and care of offices, . . . . .	3,606 76
Miscellaneous expenses, . . . . .	194 20
Deer Island pumping station: —	
Labor, . . . . .	11,383 41
Coal, . . . . .	5,521 97
Oil and waste, . . . . .	328 21
Water, . . . . .	1,025 47
Packing, . . . . .	309 28
Repairs and renewals, . . . . .	564 88
Telephones and office supplies, . . . . .	243 06
Miscellaneous supplies and expenses, . . . . .	1,243 58
East Boston pumping station: —	
Labor, . . . . .	10,802 51
Coal, . . . . .	7,357 59
Oil and waste, . . . . .	361 88
Water, . . . . .	1,056 60
Packing, . . . . .	72 37
Repairs and renewals, . . . . .	486 82
Telephones and office supplies, . . . . .	148 93
Miscellaneous supplies and expenses, . . . . .	683 12
Charlestown pumping station: —	
Labor, . . . . .	10,743 81
Coal, . . . . .	3,316 97
Oil and waste, . . . . .	291 85
Water, . . . . .	405 60
Packing, . . . . .	182 05
Repairs and renewals, . . . . .	339 53
Telephones and office supplies, . . . . .	217 43
Miscellaneous supplies and expenses, . . . . .	1,971 14
Alewife Brook pumping station: —	
Labor, . . . . .	3,307 79
Coal, . . . . .	1,382 17
Oil and waste, . . . . .	147 79
Water, . . . . .	150 48
Packing, . . . . .	41 56
Repairs and renewals, . . . . .	70 55
Telephones and office supplies, . . . . .	160 79
Miscellaneous supplies and expenses, . . . . .	152 12
Sewer lines, labor, . . . . .	21,529 06
Supplies and expenses, . . . . .	5,057 81
Horses, vehicles and stable account, . . . . .	3,752 29
Total, . . . . .	\$117,517 07
<i>South Metropolitan System — Maintenance.</i>	
Administration: —	
Commissioners, secretary and assistants, . . . . .	\$5,710 00
Postage, printing, stationery and office supplies, . . . . .	636 55
Rent, telephone, heating, lighting and care of building, . . . . .	1,151 73
Miscellaneous expenses, . . . . .	1,255 80
<i>Amount carried forward,</i> . . . . .	\$8,754 08

GENERAL CHARACTER OF EXPENDITURES.	For Year ending December 31, 1905.
<i>Amount brought forward,</i> . . . . .	\$8,754 08
<i>South Metropolitan System — Maintenance — Concluded.</i>	
General superintendence: —	
Engineer and assistants, . . . . .	4,260 91
Postage, printing, stationery and office supplies, . . . . .	353 23
Rent, telephone, heating, lighting and care of offices, . . . . .	661 90
Miscellaneous expenses, . . . . .	119 45
Sewer lines, labor, . . . . .	9,949 35
Supplies and expenses, . . . . .	1,834 29
City of Boston, for pumping and interest, . . . . .	72,318 85
Horses, vehicles and stable account, . . . . .	2,230 18
Quincy pumping station: —	
Labor, . . . . .	4,244 24
Coal, . . . . .	1,580 00
Oil and waste, . . . . .	47 40
Water, . . . . .	329 96
Packing, . . . . .	42 23
Repairs and renewals, . . . . .	155 81
Telephones and office supplies, . . . . .	122 68
Miscellaneous supplies and expenses, . . . . .	1,878 46
City of Boston, for discharge of sewage, . . . . .	622 21
Ward Street pumping station. —	
Labor, . . . . .	14,453 34
Coal, . . . . .	8,199 80
Oil and waste, . . . . .	878 19
Water, . . . . .	1,117 20
Packing, . . . . .	98 81
Repairs and renewals, . . . . .	247 58
Telephones and office supplies, . . . . .	239 10
Miscellaneous supplies and expenses, . . . . .	4,488 40
Nut Island screen-house: —	
Labor, . . . . .	4,632 99
Coal, . . . . .	920 50
Oil and waste, . . . . .	51 45
Packing, . . . . .	9 68
Telephones and office supplies, . . . . .	223 15
Miscellaneous supplies and expenses, . . . . .	899 88
Water, . . . . .	106 92
Repairs and renewals, . . . . .	3 84
Total, . . . . .	\$146,076 06

## (b) Receipts.

The receipts from the sales of property, from rents and from other sources, have been credited as follows: —

ACCOUNT.	For Year ending December 31, 1905.	From Beginning of Work to December 31, 1905.
North Metropolitan System — construction, . . . . .	\$129 87	\$17,153 40
South Metropolitan System — construction, . . . . .	644 28	6,622 27
North Metropolitan System — maintenance, . . . . .	1,821 00	7,176 53
South Metropolitan System — maintenance, . . . . .	885 57	1,027 43
Metropolitan Sewerage Loans Sinking Fund, . . . . .	75 00	835 20
Totals, . . . . .	\$3,555 72	\$32,814 83

(c) *Assets.*

The following is an abstract of the assets of the Sewerage Works, a complete schedule of which is kept on file in the office of the Board : —

Office furniture, fixtures and supplies; engineering and scientific instruments and supplies; horses, vehicles, field machinery, etc.; machinery, tools and other appliances and supplies; real estate connected with works not completed; completed works, including real estate connected therewith.

(d) *Liabilities.*

There are liabilities as follows : —

Current bills unpaid, . . . . .	\$6,460 24
Due on monthly pay rolls, . . . . .	610 55
	<hr/>
	\$7,070 79

*Amounts on Monthly Estimates, not due until Completion of Contracts or until Claims are settled.*

NAME.	Work.	Amount.
High-level Sewer : —		
J. W. Bustin & Co., . . . . .	Sect. 57, reserved for repairs,	\$100 00
National Contracting Co., . . . . .	Sect. 73, contract abandoned,	5,516 17
E. W. Everson & Co., . . . . .	Sect. 75, . . . . .	1,000 00
Allis-Chalmers Co, . . . . .	Sect. 77, . . . . .	51,000 00
		<hr/>
		\$57,616 17

On the claims of the following it is impossible to state the amounts due for land and other damages, as no sums have been agreed upon,



and suits are now pending in the courts for the determination of most of them: —

Holyhood Cemetery Association, Boston Elevated Railway Company, Boston & Maine Railroad, Mary Rohan, Mary E. Connolly, National Contracting Company, Jacob M. Mason, Martin Dings, Anna L. Dunican, Emma Dings, Carrie S. Urquhart, N. Jefferson Urquhart, Edwin N. Urquhart, Mary Doherty, Mary E. Doherty, Richard Jones, James Doherty, Michael Niland, Fred W. Baker, Catherine A. Baker, Walter J. Baker, Freda E. Baker.

### VIII. CONSUMPTION OF WATER.

The average daily quantity of water consumed in the cities and towns supplied by the Metropolitan Water Works during the year was 118,398,000 gallons, an increase of 3,489,000 gallons per day over that of the preceding year. The consumption during the year was 131.2 gallons per inhabitant per day, as against 129.4 gallons<sup>1</sup> in the preceding year. The increase seems to have occurred almost entirely in the southern high-service district and in the northern and southern extra high-service districts, the last comprising the highest portions of West Roxbury and Milton. The maximum consumption of water in winter occurs when the temperature is lowest, and the summer maximum, though less than that of the winter, is reached during periods of drought.

The measurement of the water supplied to each municipality in the District, which the Board has been able to make by the use of the Venturi meters, has shown results similar to those reported for the preceding year. An examination of the tables, giving the amounts of water consumed by the different municipalities in different months of the year and hours of the day, shows conclusively the absolute waste which occurs in many parts of the District. It is noticeable that the tables show in the coldest weather of the year a rate of consumption between the hours of 1 and 4 in the morning abnormally high, although during these hours but very small quantities of water are used for any legitimate purposes. The waste is shown to occur

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<sup>1</sup> The consumption per capita as stated in last year's report was less than the amount here given, as the estimate of population was found too large, and has been corrected by the recent census.

The figures of consumption given here are for all of the water delivered from the various sources of supply, and they slightly exceed the figures of the quantity of water delivered to the different municipalities as measured by the Venturi meters.

not only from allowing the water to run continuously in the coldest season in order to avoid the freezing of the pipes, but also from defective fixtures in houses, and leakages in the local systems. It is estimated that one-half of the increase in the consumption of water during the past year over that of the preceding year is attributable to the increase in the amount of leakage and waste, and not to the growth of population or necessary uses.

In its preliminary report made to the Legislature at the beginning of the present year the Board called especial attention to the desirability of legislation for the prevention of waste and excessive use of water, and advised that, for the purpose of promoting this end, further change should be made in the basis of assessments. Its report upon this subject was as follows : —

The time not only when certain impending expenditures will be required, but also when the District will be called upon to seek additional sources of water supply, are both dependent upon the rate of consumption of water in the various municipalities of the Metropolitan Water District.

In the year 1894, when the State Board of Health made its report, the average rate of consumption per capita in the municipalities now constituting the District was 88 gallons per day; and it was estimated that an average quantity of 100 gallons per capita as a rate of consumption would be required in the year 1920, and this amount was the assumed rate for the succeeding years, so that 100 gallons per capita per day was the quantity declared proper to be used in estimating the requirements of the succeeding thirty years. It was upon this basis that the calculations as to the capacity required and the time for which the works recommended would be sufficient were made.

The average rate of 100 gallons per capita per day was actually reached in the year 1896; and in the year 1905 the average rate in the District was 129 gallons per capita, and in the city of Boston the rate of consumption reached the amount of 151 gallons.

The Board is still of the opinion, from the careful investigations which have been made, that 100 gallons per capita per day are ample, and indeed more than ample, for all the proper needs of the District, and that it is both possible and practicable to prevent the unnecessary use and waste which make up the excess.

In the lack of further legislation, the remedy for the over-consumption lies with the local authorities of the various municipalities of the District.

In the year 1904 the Legislature changed in part the basis upon which the assessments upon the various cities and towns were fixed. It was pro-



vided that, beginning with the year 1906, assessments should be made in the cities and towns other than Boston, one-third in proportion to their respective valuations, and two-thirds in proportion to the quantity of water respectively consumed by them, the Legislature of that year substituting, so far as these cities and towns were concerned, consumption as an element of assessment instead of population. The assessment of the city of Boston remained as originally fixed, being based upon the proportion which its valuation bears to the total valuation of the District.

It is believed by the Board that the time has come when the principle of consumption should be made an element in the assessment of Boston, as well as in the assessments payable by the other cities and towns. The reason why a certain discrimination was made in the original act against the city of Boston, because the act provided that the works of water supply of that city should be taken and paid for, has now lost much of its force.

It is believed that making consumption an important element in the question of assessment will not only tend to decrease the consumption in the city of Boston, but prove the most effective means of postponing the large expenditures which may be required in the future. Although the act of the year 1904 takes effect in the current year, the good results which have come from the enactment of the statute have been already seen in the movements which have been begun in several of the municipalities, looking to the introduction of meters, and a more rigorous inspection in the interest of decreasing the yearly assessments.

The application of meters and more careful inspection are greatly to be desired, and it is far preferable that these should be supplied by the action of the local authorities than compelled by general legislation.

The Board urges not only the desirability of general legislation, but also urges upon the various municipalities of the District the adoption of measures, through the introduction of meters, rigorous inspection or otherwise, which shall tend to decrease the unnecessary consumption, and to save unnecessary burdens which fall not only upon the people of the District itself, but, in case of uncalled-for extensions of works, upon residents of other portions of the Commonwealth, whose lands are taken, whose other properties are affected in value, and whose business interests are impaired.

## IX. ELECTROLYSIS.

Investigations and experiments have been continued relative to the extent of the injury done to the water pipes by the underground electric currents, and for the purpose of overcoming or reducing



the injuries which have resulted. The investigations have been made especially as to the injury or disintegration caused by the return currents of the electricity given off by the electric railway lines.

Although in no case during the past year have sections of pipe been found so pitted and decomposed as to compel their replacement or render their continuance hazardous, it appears that the process of disintegration is steadily going on, especially in the vicinity of the electric power stations. Experiments which were begun in the preceding year in co-operation with one of the railway companies, as to the effect of the application of insulating joints, were continued. The result has indicated that, while some benefit has been experienced upon the portions of the pipes directly affected by the insulating joints, other injuries have resulted, and there has been a distribution of the damage over more remote portions, where it is still more difficult to locate the trouble. Other means must be adopted to protect the pipes from the serious injury impending. The trouble is not confined to the water pipes of the Metropolitan Works, but it is arising on the local systems of different kinds throughout the District and State.

#### X. MOTH SUPPRESSION.

Much work has been required for the suppression of the ravages of the gypsy and brown-tail moths, the region about Spot Pond in Medford and Stoneham being within the portion of the State which has been especially infested by the moths.

Near the end of the preceding year there was begun a systematic but discriminating cutting of the very thick growth of trees which bordered the pond upon the west and south, and at the same time much of the dense underbrush was removed. This work was undertaken not only for the purpose of reducing the number of trees to be protected, but also for the general improvement of the wooded areas. Thus considerable firewood was obtained and sold. Much of the wood, which was badly infested, as well as the brush, had to be burned.

The area about Spot Pond, on which the moths had appeared to a greater or less extent, embraced about 200 acres. There were, however, about 80 acres which were worst affected, principally by the gypsy moths; and upon these areas active work was begun in

February for protecting the trees by applying creosote to the egg clusters, by placing bands of burlap about the trees and in some cases also by encircling them with tanglefoot, and by spraying the foliage with disparene. Notwithstanding these efforts, many of the caterpillars escaped, and further applications of tanglefoot were made and the spraying was continued until the middle of the summer.

The spraying of the trees was accomplished with hose by the use of a portable steam boiler and steam pump connected with two 300-gallon tanks, in which the disparene was mixed with water in the proportion of one part of disparene to ten parts of water. The mixture was conveyed from the pump to the place of application through iron pipes, to which were connected rubber hose and nozzles. At first the water was brought from the pond by water carts, but later it was found more economical to install a second boiler and pump near the pond.

At several points windrows of hay sprinkled with gas oil were laid along the boundary line of the Board lands, to prevent the caterpillars from entering from the surrounding lands which had not been adequately protected.

As the result of these measures, the tract of 80 acres was but very little injured, and it is hoped that a moderate amount of work in the coming season will keep the trees on this land in good condition.

Some portions of the remaining land west of the pond are still badly infested with both the gypsy and brown-tail moths; and in the latter part of November the work of protection was resumed by applying to the eggs of the gypsy moths a mixture of equal parts of creosote and gas oil, and by cutting off and burning the nests of the brown-tail moths.

Similar work has been performed upon the lands about Mystic Lake and the Mystic Reservoir in Medford and Somerville, where both the gypsy and brown-tail moths have appeared.

The lands about the Chestnut Hill Reservoir had also been attacked by the brown-tail moths, and considerable work has been done in destroying their nests. The spraying of the foliage has been done by arrangement with the Boston Park Commission. The gypsy moth has made its first appearance in this region during the past season.

Beginning with the end of the preceding year, the sum of \$10,123.76 was spent in the work above described. Of this amount, however, about \$3,800 was expended in the cutting of the trees and underbrush. The sum of \$959.43 has been received from the sale of firewood, and wood estimated to be worth \$400 remains on hand. The sum of \$491.08 was expended on account of the work about the Mystic lands, and \$482 on the lands about the Chestnut Hill Reservoir.

#### XI. APPORTIONMENT OF ANNUAL ASSESSMENT FOR THE SOUTH METROPOLITAN SEWERAGE SYSTEM.

The Commissioners appointed by the Supreme Judicial Court to apportion among the cities and towns constituting the South Metropolitan Sewerage District the proportions which each should pay during the period comprising the years 1905 to 1909 inclusive, on account of the annual assessment necessary for the payment of the interest and sinking fund requirements and of the cost of maintenance and operation, made their report on June 9, 1905. The Commissioners followed the same conclusions which had been reached by the previous commission of apportionment for the South Metropolitan System, and by the three commissions previously appointed for the North Metropolitan System, in fixing the payments for the interest and sinking fund requirements, that is, for the cost of construction, according to the respective valuations of the municipalities, and the payments for the cost of maintenance and operation according to their respective populations.

Provision will have to be made during the present year for a new apportionment of the assessments for the North Metropolitan District. Inasmuch as all the five commissions appointed to make the apportionment since the beginning of the works have adopted the same bases of apportionment, there would seem to be good reason why the matter should now be fixed by legislation, and the considerable expenditures attending the appointment of commissions should be saved to the District.

The report and award of the Commissioners for the South Metropolitan Sewerage District are found as Appendix No. 7.



## XII. RECOMMENDATIONS FOR ADDITIONAL WATER LOANS AND OTHER LEGISLATION.

The Board, in its preliminary report to the Legislature of the year 1906, recommended that provision be made for further additions to the Metropolitan Water Loan Fund for future construction and acquisition of works. The recommendations were as follows : —

It appears from the financial statement that on January 1, 1906, a balance remains on account of the Metropolitan Water Loan Fund, for the construction and acquisition of works, amounting to \$1,079,551.27. The Wachusett Dam and Reservoir have now so nearly reached completion that the construction of the dam and reservoir will be entirely finished during the coming season. Nearly all of the other work which, by the Metropolitan Water Act of 1895, was contemplated to be performed during the first ten years, has already been completed.

For the construction of the system of Metropolitan Water Works, “substantially in accordance with the plans and recommendations of the State Board of Health,” as contained in their report for the year 1895, careful estimates were made. When the Legislature enacted the Metropolitan Water Act in the year 1895, the Board, in addition to building works as recommended by the State Board of Health, was required to take and pay for the works held by the city of Boston for the purposes of a water supply, as well as Spot Pond and the lands under and surrounding the same, owned by the cities of Malden, Medford and Melrose, and to make various other lesser expenditures, for which no estimates were made. Subsequent Legislatures have made still further requirements calling for large expenditures, for which also no appropriations whatever were provided.

The State Board of Health estimated the cost of the works called for by its recommendations to be \$19,045,800; and the cost of an aqueduct to Weston, to be constructed within ten years, with main pipes extending to the distributing system, to be a further amount of \$4,982,000. An additional expenditure for the second ten years was estimated to require a sum of \$1,300,000.

The Act of 1895 made provision for the issue of bonds to the amount of \$27,000,000. Subsequently, in the year 1901, after a settlement had been effected with the city of Boston, under which it was provided that \$12,768,948.80 should be paid for its water works taken, in addition to \$1,157,921.59 before paid that city in reimbursement, and \$1,884,320.68 required for the completion of its unfinished works, making a total of \$15,811,191.07, provision was made for a further issue of bonds to the amount of \$13,000,000, making the total issue authorized up to the present

time \$40,000,000, to the proceeds of which is to be added certain receipts applied to the Water Loan Fund, which have now amounted to \$123,765.50.

Spot Pond and the lands and water works adjacent were taken from the cities of Malden, Medford and Melrose on January 1, 1898, and negotiations were soon begun by the Board looking toward a settlement of the claims of these cities for compensation. In December of the year 1899 these cities brought suits against the Commonwealth for the recovery of damages on account of the takings of 1898. The suit of the city of Medford also included damages on account of the taking of some additional land, made in August, 1899; and on May 11, 1904, a further suit for a comparatively small amount of damages on account of the taking of some additional lands and rights from the city of Medford was brought by that city.

Subsequently, on August 9, 1901, after the settlement had been effected with the city of Boston, the Board, with the assent of the Attorney-General, offered to settle with these cities upon substantially the same basis upon which payment had been made to the city of Boston for its works, namely, the cost of the works taken, together with interest at  $3\frac{1}{2}$  per cent., from November 1, 1900, this being the extent of the offer which the Board deemed that it was then justified in making.

The total cost of their works, under computations made from the statements received by the Board from the three cities, was \$287,630.57; and the interest accrued from November 1, 1900, to the date of the offers, would have amounted to \$7,774.02 additional. These offers not being accepted, the claims continued to be prosecuted under the suits brought in court.

The auditors appointed by the court to determine the amount of the damages sustained, after a prolonged hearing, on June 19, 1905, filed their award, by which they gave to the three cities a total sum in damages of \$875,452.75, to which was added interest from the date of the takings to the date of the award, of \$364,027.16, the principal and interest amounting to \$1,239,479.91. There had, however, been paid, principally under chapter 317 of the Acts of the year 1904, providing for partial payments in cases of takings under the right of eminent domain in advance of the judgment of a judicial tribunal, the sum of \$342,820.68, so that under the award of the auditors there remained to be paid, as of June 19, 1905, the sum of \$896,659.23. The Board has been called upon to pay legal expenses, as nearly as can now be determined, in addition to the above total, amounting to more than \$41,000.

Though the amount of the award had, under the advice of the engineers and experts whom it consulted, been deemed by the Board very greatly in excess of the sum believed to be due to these cities as proper compensation for their property taken, the Board, acting according to the advice of the



Attorney-General, has now assented to a settlement by which the sum of \$896,659.23, named as due on June 19, 1905, shall be paid, but no further interest shall be payable. Seventy per cent. of this amount is to be paid directly, and the balance at a later date.

Inasmuch as the payment of the amount remaining due under the Spot Pond award will leave a sum insufficient to provide for the payment of indebtedness already accrued and the completion of works now in progress, and for the construction of such works as are believed to be required for the coming year, so that it will become necessary in any event that an additional loan fund shall now be authorized, the Board has deemed it proper to present a statement of the works which it now seems may be required during a series of years to come. It is of course impossible to state with exactness the cost, especially of works to be constructed in the undetermined future, or to estimate correctly the amount of demands which are subject to the decisions and judgments of the courts.

It is estimated that there will be required sums as follows : —

*Works completed, in Progress and deemed called for in the Coming Year.*

For the payment of claims and reserves under completed contracts, for the completion of contracts and work now pending, for damages under suits and claims still unsettled, and for administration, engineering and legal expenses connected with the above, the sum of . . . . .	\$345,000
For various works which will be required during the coming season for the completion of the Wachusett Dam and Reservoir, with the necessary administration and engineering expenses, . . . . .	50,000
For the Chestnut Hill and Arlington pumping stations, and other work in connection with the aqueducts and pipe lines, . . . . .	38,000
For the drainage of swamps in both the Wachusett and Sudbury watersheds, the construction of filter-beds and other works for the prevention of pollution, which the Board believes are demanded for the sanitary improvement of the system, . . . . .	200,000
For the construction of a masonry tower around the Arlington stand-pipe, which the Board believes to be desirable, . . . . .	40,000
Total, . . . . .	\$673,000

The payments and works covered by the first three items in the above list, and a portion of the fourth item, seem absolutely required. The fourth and fifth items relate to works upon which construction has not been begun, but which the Board believes should certainly or properly be undertaken during the coming year.

There are other works for the distribution of water which have not been entered upon, but which will probably be required sooner or later during the period of the next few years. The time when these works will be re-



quired is dependent upon the success of the efforts which may be made for checking or lessening the waste and unnecessary use of water. Should the consumption of water go on increasing at the rate at which it has increased during the past ten years, a portion at least of these should be begun early in the period. These requirements are as follows : —

*Works not yet begun, but needed from Time to Time, in the Next Few Years.*

For a main pipe line from Weston Aqueduct to Medford, . . .	\$850,000 00
For an additional pipe line from Everett to Revere, . . .	40,000 00
For a new pumping engine at the high-service station at Chestnut Hill Reservoir, . . . . .	150,000 00
For a new pipe line from Medford to Malden, . . . . .	150,000 00
Total, . . . . .	<hr/> \$1,190,000 00

There is another class of works, the construction of one or another of which may be called for at a short notice, or may perhaps be deferred for a considerable period to come. The town of Hyde Park and the city of Newton are parts of the Metropolitan Water District, and pay partial annual assessments, but as yet have not called for a water supply. Whenever they deem that their own sources are insufficient, the Board is required to furnish them water. So, also, any city or town not now embraced within the District, but situated within the ten-mile limit, must be admitted to the District, and receive a water supply on payment of such sum as the Board may determine, the sum so received not being applied to the Metropolitan Water Loan Fund, but being distributed back to the cities and towns composing the District.

Inasmuch as these demands, though uncertain, may any of them be suddenly made, it would seem that a proper appropriation therefor should now be authorized for use when the occasion arises.

*Works required when Additional Cities and Towns call for a Water Supply from the Metropolitan Water Works.*

For a pipe line to supply the town of Hyde Park, . . . . .	\$100,000 00
For pumping machinery and pipes to supply the city of Newton, . . . . .	115,000 00
For works which may be required upon admission of municipalities to the District, say, . . . . .	100,000 00
Total, . . . . .	<hr/> \$315,000 00

The requirements, therefore, including those which may be called for during a period of years to come, are now estimated by the Board as follows : —

For the payment of the Spot Pond award, . . . . .	\$896,659 23
For payments and construction during the coming year, . . . . .	673,000 00
For works for which the time of construction is dependent upon the consumption of water, . . . . .	1,190,000 00
For works for which the time of construction is dependent upon the demands of municipalities, . . . . .	315,000 00
Total, . . . . .	<u>\$3,074,659 23</u>
Deduct balance of Metropolitan Water Loan Fund on January 1, 1906, . . . . .	1,079,551 27
Total, . . . . .	<u>\$1,995,107 96</u>

If the policy which has heretofore prevailed should now be adopted, of authorizing a loan sufficient for the needs of a considerable period to come, under which bonds can be issued by the Treasurer of the Commonwealth from time to time as the works are called for, the amount of the appropriation which should now be authorized is \$2,000,000.

It is to be noted that, in making the foregoing estimates relative to the requirements for the future, the Board has included no estimates for the acquisition of new sources of water supply, the demand for which will be hastened or delayed according to the rate of consumption, nor has it included the amount which may be needed for machinery for the production of power at the Wachusett Dam.

The amount that would be needed for the latter purpose, and the time when such production might begin, are still problematical. It is also questionable whether the amount which may be required for such machinery, which would be expended, not for purposes of a water supply, but for the making of profit, should be taken in the same manner as in other cases, from the water loan fund. For the carrying on of such work for profit the Board is of an opinion that further authorization should be given by the Legislature.

The Board further recommended the passage of legislation by which it should be provided that all payments of money hereafter received from municipalities on account of their admission into the Metropolitan Water District, and the initial payments on account of water furnished to water companies, as well as all premiums received from sales of bonds issued for the construction both of water works and of sewerage works, should be applied to the respective loan funds, and not, as now provided, to the diminution of the annual assessments, as follows: —

The Metropolitan Water Act, section 3 of chapter 488 of the Acts of 1895, provided that all payments of money determined by the Board to be due from a municipality upon its subsequent admission into the District should be distributed to the cities and towns in proportion to the total amount of the annual assessments paid by them respectively. Inasmuch as the payment of money determined to be due on admission of a city or town to the District is largely determined by the additional amount which will be required for the extension of the system to the municipality, there seems to be no reason why, as the cost of such extension is payable out of the Water Loan Fund, the sum received on this account should not be payable back into the loan fund. The present provision, under which the sums so collected are deducted from the assessments of the year, also causes a decrease in the amount of the annual assessment which is rather seeming than real.

Section 18 of the Metropolitan Water Act provides that any premiums received from sales of bonds issued for the construction of the works shall be applied to the diminution of the charges for interest, sinking fund requirements and expenses of maintenance and operation of the works. Although there may have been at the outset reason for this application of sums received from premiums, it would seem more just that money received in this way should be paid, like the principal, into the loan fund.

The Board respectfully recommends that provision be made by which the sums received by the Treasurer from these two sources should be paid into the loan fund.

A similar recommendation was made relative to the application of premiums from the sale of bonds issued on account of the Metropolitan Sewerage Loan : —

The Board repeats the recommendation which it has made in the foregoing pages of this report relating to the water works, — that any premiums received from sales of bonds issued for the construction of works shall be paid, like the principal, into the loan fund, and not be applied to the diminution of the charges for interest, sinking fund requirements and expense of maintenance and operation of the works for the current year. In the case of the sewerage works, more than in the case of the water works, much trouble has resulted in the past from the variation in the amounts actually assessed in successive years, which has arisen from the application of the amounts received in premiums from the sale of bonds to the diminution of the assessment for the year. In two successive years the amounts paid in premiums were, in one of the years, 49 per cent. of the total amount of interest, sinking fund requirements and maintenance expenses, and in the other year 41 per cent. of the total amount. Variations of less amounts have occurred in other years. Great disturbance and annoyance



have thus been caused to the local authorities, who base coming appropriations to be required for their municipalities upon the payment made for the preceding year.

The Board further recommended that it be permitted, while conforming to the statute of chapter 211 of the Acts of the year 1905, providing that the fiscal year of departments and boards should begin on the first day of December and end on the thirtieth day of November, and making its report thereon, including a statement of its recommendations regarding matters of legislation, to make in the month of February its detailed statement of the year's operations, with the statistical tables accompanying it, for the calendar year preceding, as follows:—

The Legislature of last year provided, by chapter 211, that beginning hereafter the fiscal year for all offices, departments, boards, commissions and institutions shall end with the thirtieth day of November; and further provided that the annual reports required of them shall be made on or before the third Wednesday in January. By the General Laws the annual reports of most boards and commissions are required to include the year ending on the thirtieth day of September. The Metropolitan Water Act, however, made a special provision in regard to annual reports. The work of construction for the year is in its most active stage in the months of September and October, and is continued, according to the weather, frequently into the month of December, when the season's work is closed. It would be impracticable, if not impossible, to make a proper detailed statement of the work accomplished during the year ending with September 30, and to call upon the engineers, who are at that time engrossed in the work of supervision and inspection, to suspend their efforts, and to collect and make up the data upon which the report must be made. This would not only seriously interfere with the season's operations, but would also add materially to their cost. Besides, the maintenance of public works of this character, especially water works, calls for the compilation and publication of tables relating to rainfall, yield of watersheds, consumption and other important statistics, which are of great importance as guides for economical comparisons and future construction and calculation, as well as of great value in court adjudications. These tables, many of them beginning with the operation of the works by the city of Boston, have been made for the calendar year, and in usual conformity with the similar statistics made for mutual use by other large cities and districts.

It has been the practice of this Board, in accordance with the special statute prescribing its duties, to present to the Legislature at the beginning

of its session a financial report of its operations, together with the recommendations which it has to offer relative to desirable legislation, as is done in the present report, and to make a more detailed report of the season's operations in the month of February. The Board recommends that it be permitted, while conforming to the statute of 1905 relative to the fiscal year, and making its report thereon, including a statement of its recommendations regarding matters of legislation, to make its detailed statement of the year's operations, together with the statistical tables accompanying it, for the calendar year, in the month of February.

### XIII. EXTENSIONS OF THE METROPOLITAN SEWERS IN THE NORTH AND SOUTH METROPOLITAN DISTRICTS.

The Board in its preliminary report to the Legislature made further recommendations relative to needed extensions of the Metropolitan sewers in both the North and South Metropolitan districts, as follows : —

The Legislature, by chapter 230 of the Acts of the year 1904, called upon the Board to determine the location, elevation and size of an extension of the Metropolitan High-level Sewer into certain of the higher districts of Brookline, Brighton and Newton. The scheme for a High-level Sewer, adopted by chapter 424 of the Acts of the year 1899, under which the present High-level Sewer has been constructed, contemplated an eventual extension of the sewer to these districts. The annual report of the Board made last year showed the location and the proposed elevation and size of such a sewer, determined in accordance with the provisions of the Act of 1904, and also contained an estimate of the cost of construction of the various portions of the work. It was then declared that the time was fast approaching when the volume of sewage discharged into the Charles River valley sewer, which provides for these districts as well as for the lower territory, will have reached the capacity of that sewer, and that the relief contemplated at the time of the passage of the High-level Sewer Act of 1899 would soon have to be afforded. A full report upon this matter is contained in the report of last year.

Although the low rainfall of the past year tended greatly to reduce the overflow of all sewers receiving rain water in addition to the sewage, these overflows occurred principally along portions of the Charles River sewer situated in Brookline and in the Brighton and Back Bay districts of the city of Boston. Some complaints have already been made of injurious effects arising from these overflows, which occurred on as many as twelve to eighteen days during the last year. The Charles River in the region



affected is now tidal, but when the Charles River Dam is either temporarily or permanently built, the result will quickly become more offensive and injurious.

If the necessary legislation for authorizing this extension should be passed by the present Legislature, the preparation of detailed plans would undoubtedly consume the remainder of the year, and the construction of the portion which it is now contemplated to build first would involve two years more; and it would certainly be two years or more after the completion of the extension before the city and town would fairly avail themselves of the relief offered by the new sewer.

The High-level Sewer Act of the year 1899 provides that cities and towns shall connect their local sewers with the High-level Sewer; and further provides that the sewerage systems of all drainage areas not now drained by the South Metropolitan System which are constructed after the passage of the act shall be constructed in accordance with the so-called separate system of sewerage. The Act passed in the year 1903 made provision for the construction by cities and towns of drains for surface or storm water separate from the sewers built for the disposal of sewage proper.

Although the plan of separate sewers to empty into the Metropolitan System, if completed, would obviate to a certain extent the overflows from the present sewer, it can hardly be expected that the municipalities will complete or even begin the construction of their separate systems in the regions affected before any provision is made for the building of the main sewer which the separate system is to enter.

The Board is of the belief, both on sanitary grounds and for providing the necessary entrance for the separate local systems, that the time has now arrived when the construction of a portion of this extension should be undertaken. The estimated cost of the entire extension, as given by the Engineer of the Sewerage Works in the report of last year, is \$1,889,906; and the cost of that portion in West Roxbury, Brookline and Brighton which would first be required was estimated at \$1,168,928. The Board therefore recommends that the Legislature authorize the construction of this extension, and the issue of bonds to the proper amount which may be required for its construction.

A comparatively small amount of construction to be begun during the present year is needed for the North Metropolitan System. When the town of Wakefield was added to this system, a new trunk line was built from the boundary between that town and the city of Melrose to a point in the centre of the city of Malden near what is known as Barrett's Pond. From this location the original Metropolitan Sewer was estimated to have a carrying capacity sufficient for both the original line and the new line for a period of five years. The construction of this new sewer was completed



in the year 1901. The time has now come when the portion of the original Metropolitan Sewer below Barrett's Pond is inadequate to carry the contents of the two sewers, and work should be at once undertaken to extend the Wakefield sewer to the tidal meadows on the southerly borders of the city of Malden, where an efficient overflow into the waters of the Malden River can be found.

It is estimated that the necessary construction will cost \$55,000; and the Board recommends that authority be given for the issuing of bonds for the North Metropolitan System for the purpose of carrying out this work.

#### XIV. FUTURE WORK.

The Wachusett Dam and the Wachusett Reservoir, which form the most important features of the scheme adopted by the passage of the Metropolitan Water Act for an additional supply of water for the Metropolitan District, will be completed and will be ready for the service for which they have been built in the current year. Owing to the unusually low yield of the watershed, the reservoir has not been filled to the extent anticipated, although sufficiently to meet all the purposes of the District. About two years of normal rainfall will probably cause the reservoir to be substantially filled.

There remain to be performed some work necessary for the entire completion of the Dam and Reservoir and some other smaller undertakings now in process of completion. Final settlement is to be effected in the dam and later reservoir contracts. There are outstanding claims and suits for various damages remaining to be disposed of. Owing to the termination of the period within which claims could be instituted, many additional suits have been brought in the past year for damage to property on account of the operations of the Board in various localities, and for damage for depreciation of value, especially of property in Boylston, under the recent act giving the owners the right to prosecute.

Considerable further work is required upon the pumping stations. It is also desirable that further attention should be given to the drainage of swamps, both in the Wachusett and Sudbury watersheds, and to the construction of filter-beds and other works for the prevention of pollution.

There will be required from time to time, accordingly as there is greater or less consumption of water, the laying of new main pipe lines and the providing of new pumping facilities, and, as demand

may be made, for water supply connections with other municipalities in the District not yet furnished with a water supply. The proposed improvement of Spot Pond Brook, called for by the Legislature of the year 1904, is still dependent upon action under the petition already filed for the appointment of a commission.

The Board believes, from careful computations which have been made by its engineers, that the cost of the works upon which estimates were originally made by the State Board of Health have not been exceeded in actual construction. This result is reached after adding to the total sum already expended on the construction of the works recommended by that Board, its estimate of the cost of the works not yet undertaken, as well as of the cost of the works which have been omitted as not necessary under the matured plans of construction. On the other hand, many of the works constructed have been built with greatly increased capacities, involving largely increased expenditures, but for which no allowances have been made.

The total sum, as the estimated cost of the Metropolitan Water Works originally given by the State Board of Health, has so far only been exceeded on account of the additional works and requirements called for by the Legislature of 1895 in enacting the Metropolitan Water Act, and by succeeding Legislatures imposing additional requirements, and notwithstanding the fact that the cost of labor and materials has considerably increased during the latter part of the period of construction. It is probable, however, that, as the works included in the original estimates which remain still to be undertaken involve chiefly expenditures for labor and materials, the cost of these works, though comparatively small in amount, will be somewhat in excess of the estimates, if the present higher prices of labor and materials continue to prevail.

There is urgent need of the extension to tide water of the trunk sewer which was originally built from the boundary line between the town of Wakefield and the city of Melrose to the centre of the city of Malden. The Board also believes that the time has come to begin the extension of the High-level Sewer into the higher districts of Brookline, Brighton and Newton, fearing that further delay may in the future endanger the public health of communities along the line of the lower Charles River valley sewer. The entering upon new work of construction is dependent upon authorization by the Legislature.

The Board is charged, in addition to the duty of construction, with the maintenance and operation of all the various works for the

supply of water to the Metropolitan Water District and for the disposal of the sewage of the Metropolitan Sewerage District.

The report of the Chief Engineer, relating to the Water Works, and the report of the Engineer of the Sewerage Works, with various tables and statistics, are herewith presented.

Respectfully submitted,

HENRY H. SPRAGUE.

HENRY P. WALCOTT.

JAMES A. BAILEY, JR.

BOSTON, February 26, 1906.



## REPORT OF THE CHIEF ENGINEER.

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*To the Metropolitan Water and Sewerage Board.*

GENTLEMEN : — The following is a report of the operations of the Engineering Department of the Metropolitan Water Works for the year ending December 31, 1905.

### ORGANIZATION.

The list of assistants reporting directly to the Chief Engineer at the end of the year is as follows : —

DEXTER BRACKETT, . *Engineer of Sudbury and Distribution Departments.*  
THOMAS F. RICHARDSON, *Engineer of Dam and Reservoir Department.*  
WILLIAM W. LOCKE, . *Sanitary Inspector.*  
BENJAMIN F. HANCOX, . *Assistant in Charge of Drafting Department.*  
SAMUEL E. KILLAM, . *Office Assistant.*

Frank T. Daniels, who has been Principal Office Assistant, resigned on December 23 to accept a similar position with the Sewerage Commission of the city of Baltimore. The work which he has done has been placed in charge of Benjamin F. Hancox.

Joseph P. Davis and Hiram F. Mills have continued as consulting engineers.

Dexter Brackett, Engineer of the Sudbury and Distribution Departments, has charge of work in connection with the construction and maintenance of the reservoirs on the Sudbury and Cochituate supplies, the Weston, Sudbury and Cochituate aqueducts, and the pumping stations, reservoirs and pipe lines within the Metropolitan District. His principal assistants are as follows : —

Charles E. Haberstroh, . *Assistant Superintendent of the Sudbury Department.*  
George E. Wilde, . . *Assistant Superintendent of the Distribution Department.*  
John W. Lynch, . . . *Engineer of Pumping Stations.*  
William E. Foss, . . . *Division Engineer.*  
Caleb M. Saville, . . *Division Engineer.*  
Alfred O. Doane, . . *Division Engineer.*

Thomas F. Richardson, Engineer of the Dam and Reservoir Department, has charge of work in connection with the construction and maintenance of the Wachusett Dam, Reservoir and Aqueduct, and the Clinton sewage disposal works. He has had the following principal assistants : —

Moses J. Look,	. Division Engineer, in charge of the construction work on the Wachusett Reservoir from January 1 to September 30, when he resigned.
Alexander E. Kastl,	. Division Engineer, in charge of the construction work on the Wachusett Reservoir from September 30.
Frank H. Trow,	. Division Engineer, in charge of work at the Wachusett Dam.
Charles A. Bowman,	. Division Engineer, in charge of force reports, maintenance and forestal work until July 8, when he resigned.
Harry J. Morrison,	. Division Engineer, in charge of inspection of removal of soil until March 7, when he resigned.
Ernest H. Baldwin,	. Division Engineer, in charge of work at Oakdale, resigned April 1.
Elliott R. B. Allardice,	. Division Engineer, in charge of the river and aqueduct gagings, and supervision of the maintenance of the Clinton sewerage plant ; since July 8 in charge of forestry and the maintenance of the Wachusett Reservoir.

At the beginning of the year the engineering force, including those engaged upon both the construction and maintenance of the works, numbered 105, and at the end of the year 65.

In addition to the engineering force, which included the engineers engaged upon the inspection of the work, other inspectors have been employed upon masonry and earthwork. The maximum number so employed at any time during the year was 5.

There has also been a maintenance force, exclusive of the engineers mentioned above, averaging 208, employed in the operation of the several pumping stations and in connection with the maintenance of the reservoirs, aqueducts, pipe lines and other work.

From time to time special gangs of men have been employed, under the immediate direction of foremen and under the general direction of the engineers, in grading and seeding the South Dike, in building a levee across the outlet of the Carvill ice pond, in grading and seeding highway slopes, constructing roadway culverts, constructing drainage ditches below the South Dike, repairing dams at the Canada and Unionville mill ponds and at Day's Mill in Holden, in cleaning weeds from the bottom of the Wachusett Reservoir, and

in forestal work. The force thus employed has averaged 43 throughout the year, the maximum number for any week being 74.

The office of the Chief Engineer and of the Engineer of the Sudbury and Distribution Departments is at No. 1 Ashburton Place, and that of the Engineer of the Dam and Reservoir Department at Clinton, Mass. The office of the Assistant Superintendent of the Distribution Department is at Glenwood, in Medford, and that of the Assistant Superintendent of the Sudbury Department at South Framingham. Branch offices for the engineering force were maintained at Oakdale and West Boylston until November 21, and at the Wachusett Dam until November 28, when they were closed.

ARRANGEMENT OF REPORT.

In continuing this report, it is the purpose to separate the work charged to the construction account from that charged to the maintenance account; but, as the work of construction and maintenance is supervised by the same principal engineers, and in very many cases the assistants are engaged upon both classes of work, it is not feasible to make a complete separation.

CONSTRUCTION.

CONTRACTS.

A detailed statement of the contracts made and pending during the year is given in Appendix No. 1. The following statement gives a summary of all the contracts charged to construction from the beginning of the work to the end of the year 1905:—

PORTION OF WORK.	Number of Contracts.	Approximate Amount.
Wachusett Reservoir, . . . . .	37	\$3,043,752 12
Wachusett Dam, . . . . .	15	1,748,257 92
Other portions of work, . . . . .	246	10,318,846 13
Totals, . . . . .	298	\$15,110,856 17

Amount of 11 contracts made in 1905 (approximate), . . . . .	\$88,259 41
Amount of 5 contracts unfinished December 31, 1905 (approximate),	1,906,075 00
Value of work done by contract from January 1, 1905, to December 31, 1905, . . . . .	309,400 52



In the case of all contracts completed up to the present time final settlements have been made without any legal controversy.

**DAM AND RESERVOIR DEPARTMENT.**

(The statement of the work of this department has been prepared by Thomas F. Richardson, Department Engineer.)

The principal work of this department has been the construction of the Wachusett Dam and the South Dike, the construction of highways in the vicinity of West Boylston and Oakdale, and the completion of the removal of soil from the Wachusett Reservoir.

**WACHUSETT DAM.**

The design of the Wachusett Dam and the contract for its construction, which was made with the McArthur Brothers Company on October 1, 1900, were described in the annual report of January 1, 1901. The plant provided for the work, and the methods of carrying on the work, both at the quarry and at the dam, were fully described in the annual report of January 1, 1902. There has been no material change in the plant or in the methods.

The total length of the masonry of the dam is 1,476 feet, made up of waste-weir, 452 feet; main dam, including terminal structures, 971 feet; and corewall, which extends beyond the terminal structures at the easterly end, 53 feet. The length of the main dam between terminal structures is 838 feet.

Following are various elevations above Boston City Base:—

Elevation of edge of coping at top of dam, . . . . .	415.0
Elevation of flow line of reservoir, . . . . .	395.0
Elevation of original river bed, . . . . .	266.0
Elevation of lowest point of foundation not in cut-off trench, . . . . .	206.7
Elevation of lowest point in cut-off trench, . . . . .	186.8

Work at the dam, which had been shut down during the winter, was resumed on March 13. Work upon the masonry, which was suspended on account of cold weather on November 28, 1904, was resumed on March 27, and the last stone in the cornice of the dam was set on June 24. The last parapet stone in the abutment and bastion was set on July 22. This practically finished the masonry, with the exception of the granolithic surface which is to form the finish of the top of the dam.

*Main Dam, Gate-chambers and Terminal Structures.*

When work upon the masonry was suspended, in 1904, the main dam had an average elevation of 396. A gap about 20 feet wide, through which passed two tracks over which stone was brought from the quarry, had been left through the masonry, the bottom of this gap being at elevation 369. A few of the coping stones of the dam had been set at the easterly end near the abutment. A large part of the terminal structure at the easterly end of the dam, known as the abutment, had been built, some of the string course stones at elevation 415.0 having been set. The corewall, extending easterly from the abutment, had been finished.

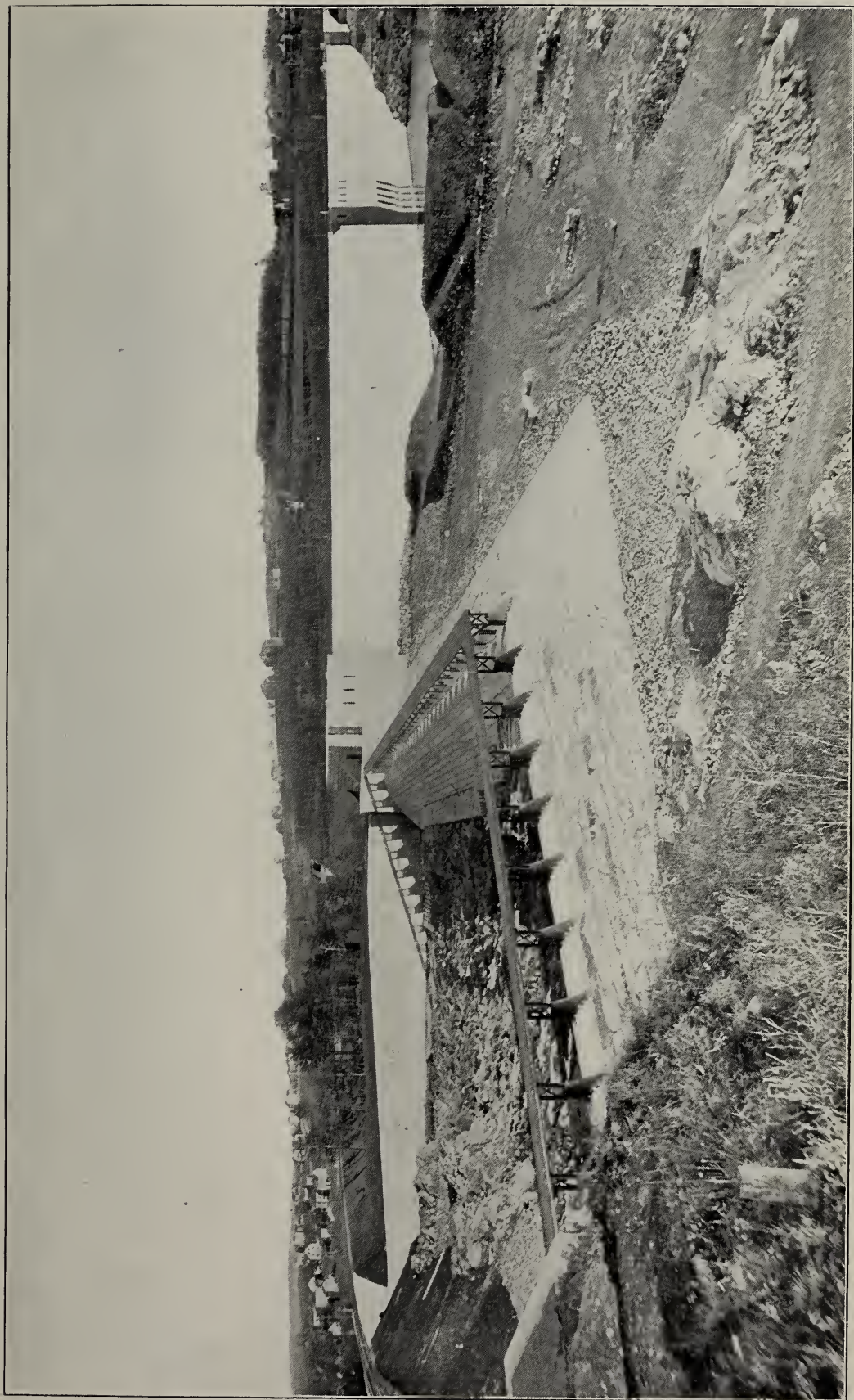
As previously stated, masonry construction was resumed on March 27. It has not been possible or necessary to work as large a force or as many derricks on the construction of the masonry as in previous years. The maximum number of derricks in operation on the masonry of the main dam and terminal structures during the year has been six. All of the rubble masonry has been laid with level beds. The tracks through the gap in the dam were taken up on May 14.

The six concrete piers for supporting the floor of the abutment have been extended. The floor, which is re-enforced with  $7/8$ -inch steel rods spaced about  $7\frac{1}{2}$  inches apart, and resting on re-enforced concrete beams which are carried by the piers, has been built. The parapet of the abutment was finished, except for the tablet stones, during the week ending July 15. The tablet stones were set on September 16. The retaining wall, extending about 200 feet up stream from the abutment, was finished during the week ending April 22.

The upper gate-chamber, the elevation of the floor of which is 2 feet 6 inches above the flow-line of the reservoir, and the top of which coincides with the top of the dam, has been completed. The interior of the gate-chamber is lined with face brick and the floor has a granolithic finish. The steelwork at the top of the wells and of the roof has been put in place, also the concrete of the roof, with the exception of the granolithic finish. An electric travelling crane for use in handling stop-planks, screens, etc., has been partially installed.

At the terminal structure at the westerly end of the dam, known as the bastion, the interior of which is finished with concrete masonry,





UP-STREAM SIDE OF WACHUSETT DAM AND WASTE WEIR.





the steelwork and concrete of the roof have been placed and the granolithic floor has been finished.

The stone masonry of the top of the dam has been levelled up with concrete masonry to about 5 inches below the finished surface, preparatory to placing the granolithic finish, which will be 5 inches in thickness.

The entire down-stream face of the dam, as far as it shows above the ground, and the up-stream face for 25 feet below the coping, have been cleaned with wire brooms and chisels.

#### *Waste Channel and Waste-weir.*

The excavation of earth and rock for obtaining a suitable foundation for the waste-weir was practically finished during the previous year, but it has been necessary to excavate a small amount of earth and rock in preparing the foundations for the small abutment at the westerly end of the weir. Considerable filling has been done on the reservoir side of the waste-weir, in preparing a foundation for the paving, the material being obtained from borrow pits in the reservoir. About the middle of May the work of excavating from the waste channel, to prepare foundations for the Central Massachusetts Railroad bridge, was begun, the excavated material being placed in the railroad embankment. On October 7 work was begun, removing from the waste channel the earth and rock upon which the cableway towers had rested, this material also being used for completing the railroad fill. On October 23, after the Central Massachusetts trains began to pass over the permanent line of the railroad, work was resumed, excavating earth and rock from the waste channel on the location of the temporary line. This work was continued with a good-sized force until the end of the year, when there remained about 1,400 cubic yards of earth and 1,900 cubic yards of rock to be removed.

The work of laying masonry on the waste-weir was resumed on March 30 and was completed on May 6, although considerable work was done pointing and trimming up the crest of the waste-weir after that date.

It was found necessary to recut the crest of the waste-weir for nearly its whole length, in order to have it true for receiving the flash-boards. Heavy cast-iron standards for supporting flash-boards have been set about 10 feet apart for the whole length of the waste-weir. The gross length of the waste-weir is 452 feet, and the net

length, after making deductions for the space occupied by the standards, is about 419 feet. The standards are arranged for carrying flash-boards 3 feet high, except for 100 feet of the waste-weir, where the crest is 3 feet below flow-line and the flash-boards are 6 feet high. The flash-boards above the level of the full reservoir are provided to prevent the waste of water from waves passing over the crest of the waste-weir. Each of the flash-board standards is secured to the top of the waste-weir by 10 bolts  $1\frac{1}{4}$  and  $1\frac{1}{2}$  inches in diameter, and also by a rod  $1\frac{3}{4}$  inches in diameter and 8 feet long for the higher part of the waste-weir, and 10 feet long for the lower part. Each rod is secured to a heavy cast-iron anchor built into the masonry on the upper face of the weir, the rod being protected from corrosion by a coating of cement mortar about 1 inch thick. Fastened to the flash-board standards are steel trestles, on which has been laid a plank walk of Georgia pine 4 inches in thickness. On this walk also there will be placed a track for a small car, to be used in transporting the flash-boards from the crest to the storage room in the bastion.

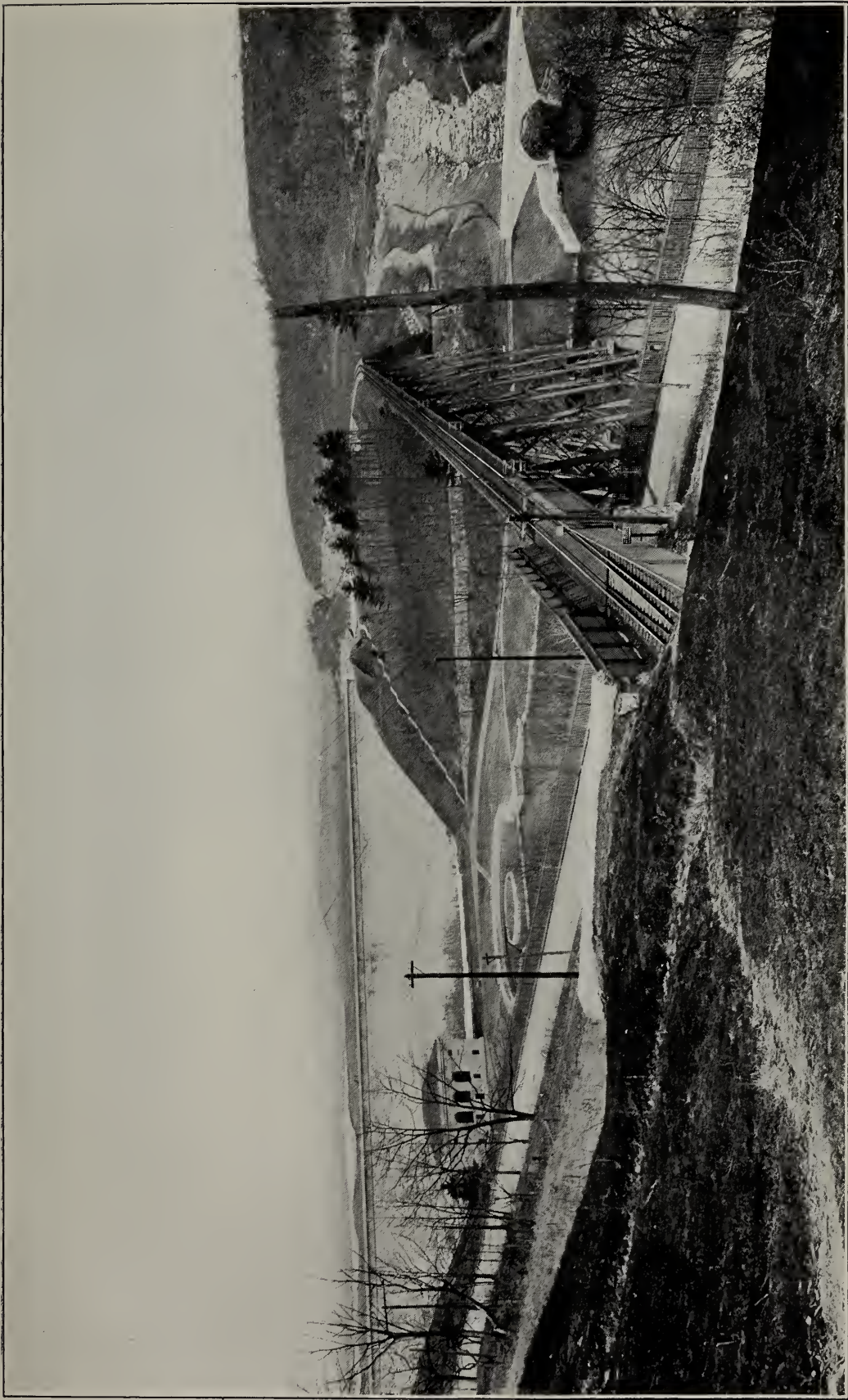
Above the waste-weir, for its whole length, is a paving of coursed granite, usually in 2-foot courses, and having a depth of from 18 to 24 inches. This paving is about 25 feet wide, and is laid on a 1 to 3 slope. Below this paving is a paving 18 inches thick, of uncoursed quarry stone, which extends to the original surface of the ground.

The retaining wall, extending along the easterly side of the waste channel from the bastion to the railroad bridge, was finished on June 10, and the small retaining walls above and below the railroad bridge were finished soon after.

#### *Arch Bridge for the Central Massachusetts Railroad.*

This bridge was not included in the original contract for the dam, but has been built by the contractor for the dam under a supplementary agreement. This bridge crosses the waste channel about 225 feet below the waste-weir, and the arch across the waste channel has a span of 58 feet. The parapet walls of the bridge are about 170 feet long, 16 feet 9 inches apart from outside to outside, and their tops are about 45 feet above the bottom of the waste channel. East of and close by the main span is an arched opening 10 feet wide under the railroad, through which passes the road to the bastion. The arches of both spans are built of Portland cement concrete, faced with granite. The parapet and wing walls are of granite masonry.





VIEW OF WASTE CHANNEL FROM WACHUSETT DAM.



*Finishing Grounds Above and Below the Dam.*

A large amount of work has been done grading the grounds below the dam on both hillsides, and above the dam on the easterly hillside. Large quantities of waste rock, dumped on the easterly hillside when the Wachusett Aqueduct and Central Massachusetts Railroad tunnels were built, have been removed and the hillside covered with soil to a depth of about 18 inches. On the westerly hillside extensive grading has been done near the bastion, and the grounds have also been covered with 18 inches of soil.

About 5,000 cubic yards of soil for finishing the grounds on the westerly hillside have been obtained from the reservoir near the South Dike, and transported across the valley by means of the cableways. Part of this soil is to be used for covering the spoil banks made from material taken from the temporary line of the railroad, and for covering the slopes of the permanent railroad embankment.

Extensive fillings have been made at the abutment at the easterly end of the dam, to make a suitable approach to the dam and to bring the grounds up to the level of Boylston Street. Gravel paths have also been constructed and foundations placed for a wide granolithic walk leading from Boylston Street to the dam.

On the easterly shore of the reservoir, above the dam, riprap 11½ feet in thickness has been placed for a distance of 500 feet, between elevations 375 and 398. Considerable quantities of riprap have also been placed above the waste-weir and on both hillsides for a distance of about 50 feet above the dam.

For draining the grounds below the dam 12 and 15 inch Akron pipes have been laid, connecting with which are 3 manholes and 12 drainage inlets. To care for the water which falls on the lower face of the dam a paved gutter has been built on both hillsides, extending from the abutment and bastion to the lower gate-chamber, and connecting with the pipe drains.

Extending from each end of the dam to the bottom of the valley are flights of granite steps. On the easterly hillside there are 187 steps, arranged in flights of 5 to 12, with granolithic platforms of varying lengths between. On the westerly hillside there are 177 steps. The steps are 5 feet long, have a 7-inch rise and are 12 inches wide, supported at the ends on concrete walls 14 inches thick



and about 4 feet 6 inches deep. The steps are anchored to the foundations by  $\frac{3}{4}$ -inch iron bolts. At the top of each third flight of steps there is a drainage inlet, which is connected with the pipes which drain the grounds below the dam.

A foundation 18 inches in depth of stone from the tunnel dumps has been placed on the road leading along the easterly side of the valley to the limits of the land owned by the Board, and this road and the roads for which foundations were built during the previous year have been surfaced with about 4 inches of screened gravel. A road having generally a rise of 10 feet in 100 has been built from the grounds below the dam to the bastion. This road is built on the steep side hill on the westerly side of the valley, and is constructed of rock excavated from the waste channel, the rock in the slopes being placed largely by hand. The road is surfaced with about 6 inches of screened gravel. Most of the slopes on the hillsides have been seeded.

*Amount of Work done and Materials used.*

The following table gives the amount of work done to the end of 1901, the amount of work done during 1902, 1903, 1904 and 1905, and the total amount of work done to the end of 1905. The final estimate for the dam has not yet been prepared, but the total amount of work done to the end of 1905, with the 1,400 cubic yards of earth and the 1,900 cubic yards of rock remaining to be removed from the waste channel, is, approximately, the total amount of work at the dam.

	To December 31, 1901.	In 1902.	In 1903.	In 1904.	In 1905.	Total to December 31, 1905.
Earth excavation (cubic yards), . . .	43,000	31,900	68,800	59,900	55,000	258,600
Rock excavation (cubic yards), . . .	24,370	12,020	18,800	36,810	7,350	99,350
Rubblestone masonry (cubic yards), . .	28,486	65,686	69,139	76,598	12,012	251,921
Ashlar masonry (cubic yards), . . .	65	684	2,015	4,905	1,147	8,816
Dimension stone masonry (cubic yards), .	-	58	417	830	1,370	2,675
Brick masonry (cubic yards), . . . .	-	407	231	398	-	1,036
Concrete masonry (cubic yards), . . .	-	5,284	1,906	914	1,621	9,725
Slope paving (cubic yards), . . . .	-	-	-	370	1,545	1,915
Iron and other metal work (tons), . . .	-	582	71	46	166	865
Roadways and paths (square yards), . .	-	-	-	460	7,660	8,120
Vitrified pipe for drains (linear feet), .	-	-	-	674	1,986	2,660

There have been used in the construction of the dam since the work began 81,103 barrels of Portland cement and 182,480 barrels of natural cement. All of the natural cement has been of the Union brand and a large proportion of the Portland cement of the Giant brand, both cements being manufactured by the American Cement Company of Egypt, Pa.

The amount of cement used in the dam per cubic yard of each class of rubble masonry from the beginning of the work has been as follows : —

COMPOSITION OF MORTAR BY MEASURE.	Barrels of Cement per Cubic Yard.	Cubic Yards built.
1 part natural cement to 1 part sand, . . . . .	1.43	184
1 part natural cement to 2 parts sand, . . . . .	0.99	179,706
1 part Portland cement to 2 parts sand, . . . . .	1.07	31,884
1 part Portland cement to 2½ parts sand, . . . . .	0.86	8,927
1 part Portland cement to 3 parts sand, . . . . .	0.78	27,954

The amount of cement used in the dam, per cubic yard of each class of concrete masonry, has been as follows : —

COMPOSITION OF CONCRETE BY MEASURE.	Barrels of Cement per Cubic Yard.	Cubic Yards built.
1 part natural cement, 2 parts sand and 5 parts stone, . . . . .	1.38	964
1 part natural cement, 3 parts sand and 6 parts stone, . . . . .	1.15	18
1 part Portland cement, 2½ parts sand and 4½ parts stone, . . . . .	1.36	7,107
1 part Portland cement, 3 parts sand and 6 parts stone, . . . . .	0.99	1,464
1 part Portland cement, 4 parts sand and 8 parts stone, . . . . .	0.70	172

### *Miscellaneous Notes.*

When the work was started early in the spring the temperature at night was frequently below freezing, and all masonry built before April 12 was laid in Portland cement mixed in the proportion of 3 parts of sand to 1 part of cement. From April 12 to May 27 the rubble masonry was laid in natural cement mortar mixed in the proportion of 2 parts of sand to 1 part of cement. After this date the small amount of rubble masonry remaining was laid in Portland cement mortar mixed in the proportion of 3 parts of sand to 1 part of cement.

The largest amount of rubble masonry laid in the dam during any week was during the week ending April 29, when 5 derricks were in operation and 1,284 cubic yards of rubble masonry were laid. During that week about 45 cubic yards of ashlar masonry were also laid. The average amount of rubble masonry laid per day by each mason has been 14.1 cubic yards, and by each derrick 57.8 cubic yards.

The stone for the ashlar and dimension stone masonry has all been obtained from the quarry of H. E. Fletcher & Co., at West Chelmsford, Mass.

The maximum force employed by the contractor was during the week ending April 29, when 368 men and 43 horses were employed.

#### *Finish of Top of Dam and Terminal Structures.*

Early in the year studies were made for different designs for a stone parapet and for a metal fence to be placed on the top of the dam. The design adopted is a fence with round posts about 5 inches in diameter, with bases  $12\frac{1}{2}$  inches in diameter, spaced 9 feet 9 inches apart, connected by two rails  $2\frac{1}{2}$  inches in diameter. The  $2\frac{1}{2}$ -inch brass tubing for the rails of the fence has been furnished by the American Tube Works, and the brass posts and anchor bolts are being furnished by J. H. McCafferty & Co. of Boston.

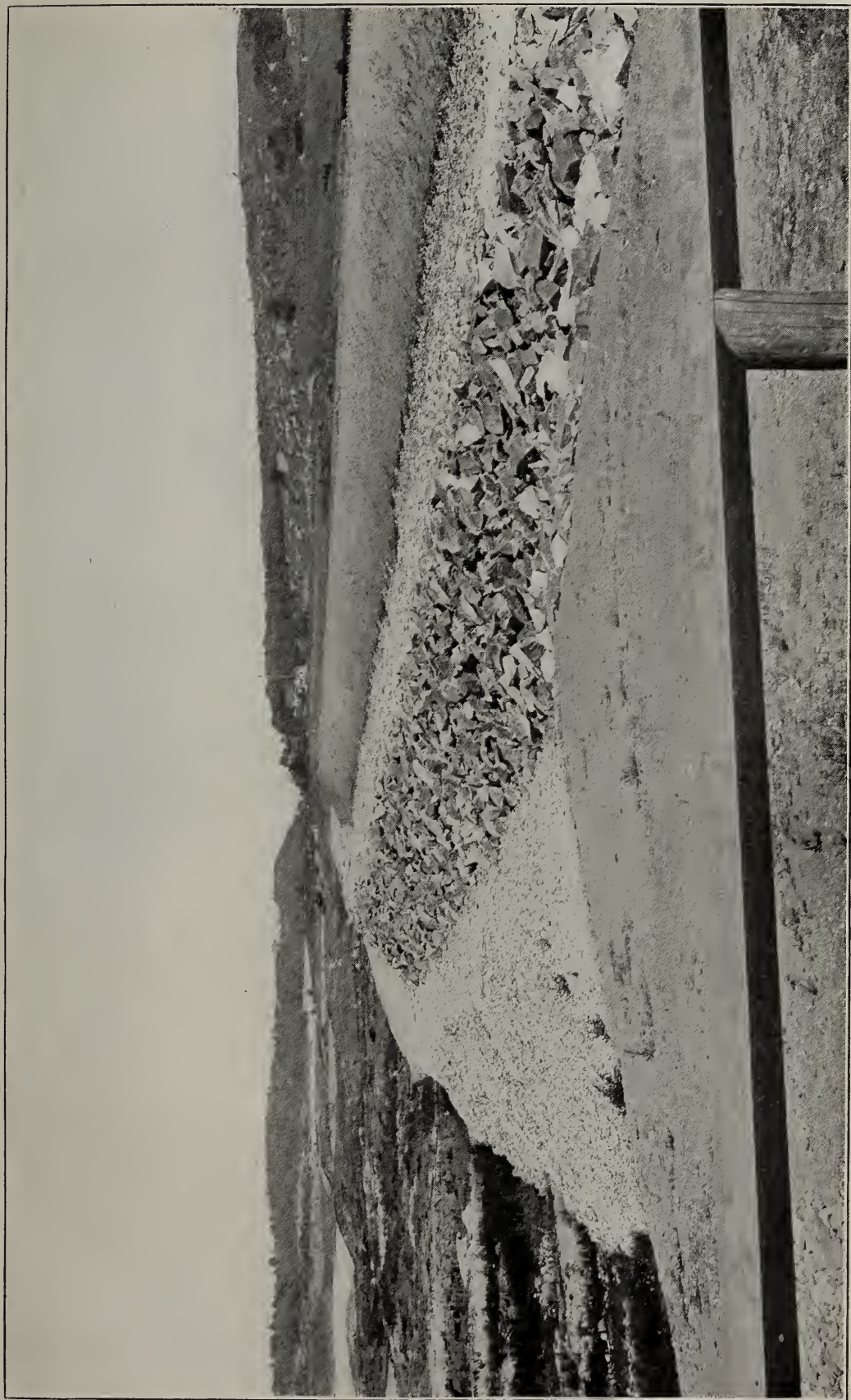
The work remaining to be done on the dam is the erection of the fence on the top of the dam, the erection of gates at the easterly end and of a fence around the platform at the bastion, and the construction of the granolithic surface on the top of the dam, including the abutment and bastion.

#### NORTH DIKE.

The construction of the North Dike was completed in 1904. A day-labor force was employed for several weeks in the spring, trimming up and seeding the westerly half of the dike, the maximum force employed being 14 men and 4 horses, for the week ending May 13.

For the purpose of obtaining the elevation of the ground water in different parts of the dike during the time that the Wachusett Reservoir is being filled, 15 wells 2 inches in diameter have been driven at different points on the dike. The deepest well has a depth of 90 feet, and the average depth of the wells is 52 feet. Observations have been taken of the elevation of the water in these wells, and will be continued as the water rises in the reservoir.





WACHUSETT RESERVOIR--VIEW OF SOUTH DIKE FROM BOYLSTON STREET IN BOYLSTON.



## SOUTH DIKE.

The South Dike was largely finished during 1904, the earthwork being completed except for filling the gap through which passed the quarry railroad used in the construction of the Wachusett Dam.

Opposite a portion of the dike the reservoir is 2 miles wide, and the face of the dike will be exposed to the action of very heavy waves.

On May 4, 1905, a contract was made with the McArthur Brothers Company, contractor for the Wachusett Dam, to place the two grades of heavier riprap on the water face of the dike. This was placed in two layers, having an aggregate horizontal thickness of 17.5 feet 4 feet below the flow-line of the reservoir, and a slope on the water face of  $1\frac{1}{3}$  horizontal to 1 vertical. The inner layer of this riprap consisted of stones containing 2 cubic feet or less, and the outer layer of stones of more than 2 cubic feet, the outer or exposed part of this last layer consisting of stones weighing a ton or more. The stone was obtained from the waste piles of the quarry from which the rubble stone for the Wachusett Dam was quarried, and was hauled to the dike on cars and placed with derricks.

The same contractor also constructed a breakwater across the outlet of the basin, formerly the Carvill ice pond, to protect a levee which was built by day labor.

Work under this contract was begun on April 29 and finished on September 30, the maximum force being 32 men, for the week ending July 8. Under this contract there were placed 11,991 cubic yards of riprap, at a cost of \$15,385.24.

Arrangements were made with the contractor for the dam to fill the gap in the dike through which the quarry railroad passed with material which he was required to remove from the embankments of his quarry railroad. This work was in progress for about three weeks, with a force of 35 men and 15 horses. About 1,000 cubic yards of material still remain to be placed to fill the gap.

Considerable work has been done with a day-labor force at the South Dike, grading and seeding where the tracks over which the riprap was hauled to the dike were laid, building a levee across the outlet of the basin, which was formerly the Carvill ice pond, and doing other work in connection with the completion of the reservoir. The levee, which is of soil re-enforced with gravel and protected by



riprap, has been built so that the water will be held in the basin when the water in the reservoir is more than 7 feet below high water. The area of the water surface above the levee is  $10\frac{1}{2}$  acres, and the water will be about  $7\frac{1}{2}$  feet deep. An iron pipe 24 inches in diameter, controlled by stop-planks in a concrete manhole, has been provided, by means of which the water in the ice pond can be drawn off if desired. This work was in progress from September 21 to November 16. The maximum force employed was 28 men and 4 horses, for the week ending October 7.

#### RELOCATION AND CONSTRUCTION OF ROADS.

The work of constructing and improving highways has been largely finished in previous years. During the past year a highway has been constructed along the southwesterly side of the reservoir, connecting West Boylston with Oakdale, the work consisting in part of improving an existing highway and in part of building a new highway. A broken-stone surface has been placed on  $2\frac{3}{4}$  miles of highways in the villages of West Boylston and Oakdale, also on a short piece of Boylston Street where it crossed the old location of the Central Massachusetts Railroad in Boylston. The grading of Holden Street, at Oakdale, has also been finished and the highway has been surfaced with gravel. All of the above work has been done by contract.

In addition to the work done by the contractors, a large amount of work has been done on highways by the day-labor forces, which included the grading and seeding of highway slopes, erecting and painting highway railings and fences in West Boylston and Oakdale, extending stone culverts, widening a high embankment on Worcester Street in West Boylston, constructing a concrete highway culvert and six pipe highway culverts between West Boylston and Oakdale, and paving gutters. The maximum day-labor force employed was 43 men and 13 horses, for the week ending June 10.

#### *Contract 282, The Newell & Snowling Construction Company.*

*Building a Part of Newton Street and improving Crescent Street, in West Boylston ;  
Date of Contract, April 21, 1905 ; Amount of Contract, \$4,812.25.*

The contract for this work, which included the building of a road extending about 2,930 feet from a point near the southerly limit of the shallow flowage embankment of soil near Oakdale to an

intersection with Crescent Street, and the improvement of Crescent Street from this intersection for about 2,110 feet to Central Street in West Boylston, was made with McBride & Co., on April 21. On April 26 McBride & Co., with the consent of the Board, assigned the contract to the Newell & Snowling Construction Company. Work was begun on April 29 and finished on June 9, and consisted of grading for the road-bed, surfacing same with a layer of selected gravel and laying pipe underdrains. The culverts were built by a day-labor force employed by the Board. The quantities of work done were as follows : —

Earth excavation (cubic yards), . . . . .	20,914
Paving (cubic yards), . . . . .	4
Laying 5-inch sewer pipe for drains (linear feet), . . . . .	2,266

The maximum force employed was 55 men and 25 horses, for the week ending May 27.

*Contracts 285 and 286, The H. Gore Company.*

*Surfacing Sections 1 and 2 of Highways, chiefly in West Boylston, with Broken Stone; Date of Contracts, May 23, 1905; Amount of Contracts, — 285, \$7,856.09; 286, \$9,790.48.*

Sections 1 and 2 are, respectively, 6,487 and 8,110 feet in length. The contracts called for surfacing with broken stone the highway beginning at the southerly end of the three-arch bridge over the Quinepoxet River, extending through the village of Oakdale and following along the northerly side of the reservoir to the junction of Sterling and Lancaster streets, and the new highway crossing the Wachusett Reservoir at West Boylston village and extending from the west side of Worcester Street on the southerly side of the reservoir to a junction with the highway first mentioned. Included in Section 2 was also a portion of Boylston Street in the town of Boylston, about 325 feet in length, located near the South Dike, at a point where the Central Massachusetts Railroad formerly passed under the street.

Work on Section 1 was begun on June 2 and finished on November 9. The maximum force employed was 27 men and 16 horses, for the week ending July 29.

Work on Section 2 was begun on July 28 and finished on November 4, except that a small amount of work still remains to be done

on Boylston Street. The maximum force employed was 29 men and 23 horses, for the week ending August 19.

The quantities of work done were as follows : —

	Section 1.	Section 2.
Shaping road-bed (linear feet), . . . . .	6,511	8,386
Broken stone in place (tons 2,000 pounds), . . . . .	4,297	5,403

REMOVAL OF SOIL.

The work of removing soil from the Wachusett Reservoir has been in progress under the contractors Bruno, Salomone & Petitti, and McBride & Co., and was entirely finished early in November.

The total amount of soil removed from the reservoir is 6,912,052 cubic yards, from 3,941 acres, of which 151,647 cubic yards were removed from 84 acres during 1905. The soil removed from the reservoir has been disposed of as follows : —

	Cubic Yards.
In road embankments, . . . . .	471,221
Filling shallow flowage areas, . . . . .	1,149,917
In railroad embankments, . . . . .	131,781
In the North Dike, . . . . .	4,955,936
In the South Dike, . . . . .	160,895
Placed in spoil banks, . . . . .	17,367
Grading grounds near Wachusett Dam, . . . . .	24,935
Total, . . . . .	6,912,052

During the year 4,720 cubic yards of earth have been deposited upon deep muck, which has been covered to a depth of about 1 foot. In previous years 238,846 cubic yards were used for the same purpose, making a total of 243,566 cubic yards.

The day-labor forces, under the direction of the engineering force, have performed the following work : —

The final cleaning of the reservoir bottom, between elevation 340 and elevation 380, of weeds, grass and bushes which had grown up since the original stripping of the soil or since the cleaning of the previous year, was done between August 20 and November 18. There were 1,460 acres of land cleaned, at a cost of \$6,210, or an average cost of \$4.25 per acre. Over a considerable area where the slopes were not sharp and where the ground was not rocky, the ground was harrowed with spring-tooth harrows, the grass, roots and brush being afterwards raked and burned. On other areas the grass, weeds and brush were mowed close to the ground, raked and



burned. Much better results were obtained with the harrows, but at a considerably greater cost. The maximum force employed on this work was 70 men and 10 horses, on September 20.

On both sides of the reservoir, near Sawyer's Mills, and on the southerly side of the reservoir, near Dover Pond, additional soil has been removed from the margins, the erosion of the water having caused the steep banks at these points to cave nearly to the limit of the original soil stripping.

Considerable areas of the bottom of the reservoir near the upper end have been graded to secure proper drainage. Boulders have been removed from the Quinepoxet channel and placed along the edge and slopes of the channel. Levees and embankments have been seeded along the Stillwater River, and much other miscellaneous work has been done.

*Contract 257, Bruno, Salomone & Petitti.*

*Section 10 of the Wachusett Reservoir, in Boylston and West Boylston.*

On December 27, 1902, a contract was made with Bruno, Salomone & Petitti for the construction of what is known as Section 10 of the Wachusett Reservoir. This contract called for clearing, grubbing and excavating soil from some 700 acres toward the upper end of the reservoir, and at the beginning of 1905 the only other soil stripping necessary to complete the reservoir was that on a small area along the Stillwater River and on a comparatively small area near the South Dike, the soil from which was reserved for use at the Wachusett Dam. In addition, this contract provided for the construction of a new channel, chiefly in rock, for the Nashua River, at the highway crossing the reservoir at West Boylston; for the excavation of earth and gravel from shallow portions of the reservoir at Oakdale; for enlarging the channel of the Quinepoxet River west of the Worcester, Nashua & Portland Division of the Boston & Maine Railroad at Oakdale; for building a concrete dam across the river at the upper end of this channel; for paving the slopes of railroad and highway embankments; and for covering with earth deep deposits of muck not desirable to remove.

During 1905 all soil and other material has been loaded into carts and hauled directly to the place of disposal, the contractor finding it more economical to do the work by this method than by the use of cars.

The total amount of soil removed under this contract was 1,273,-620 cubic yards, of which 269,366 cubic yards were used in highway embankments, 986,887 cubic yards in shallow flowage embankments at Oakdale, and 17,367 cubic yards were placed in spoil banks.

The contractor resumed the excavation of soil on April 3, and this part of the work was practically completed on September 2, the soil having been placed largely in shallow flowage embankments. Considerable soil was also used in dressing the margins of the reservoir near the Worcester Street crossing.

The principal work under this contract during the year has been the enlargement of the Quinepoxet River channel and the building of the concrete dam at the upper end of the same. The material encountered in the channel excavation, much of which was hardpan with numerous large boulders, has been used mainly for facing the shallow flowage embankments. Some of the material has also been used for building a berm along the Central Massachusetts Railroad above Oakdale and for surfacing Holden Street. The concrete masonry of the dam was finished on September 22 and the slope paving above and below the dam on October 14. Water was turned over the dam on the latter date. The slope paving at the Worcester Street embankment in West Boylston and along the Worcester, Nashua & Portland Division has been completed.

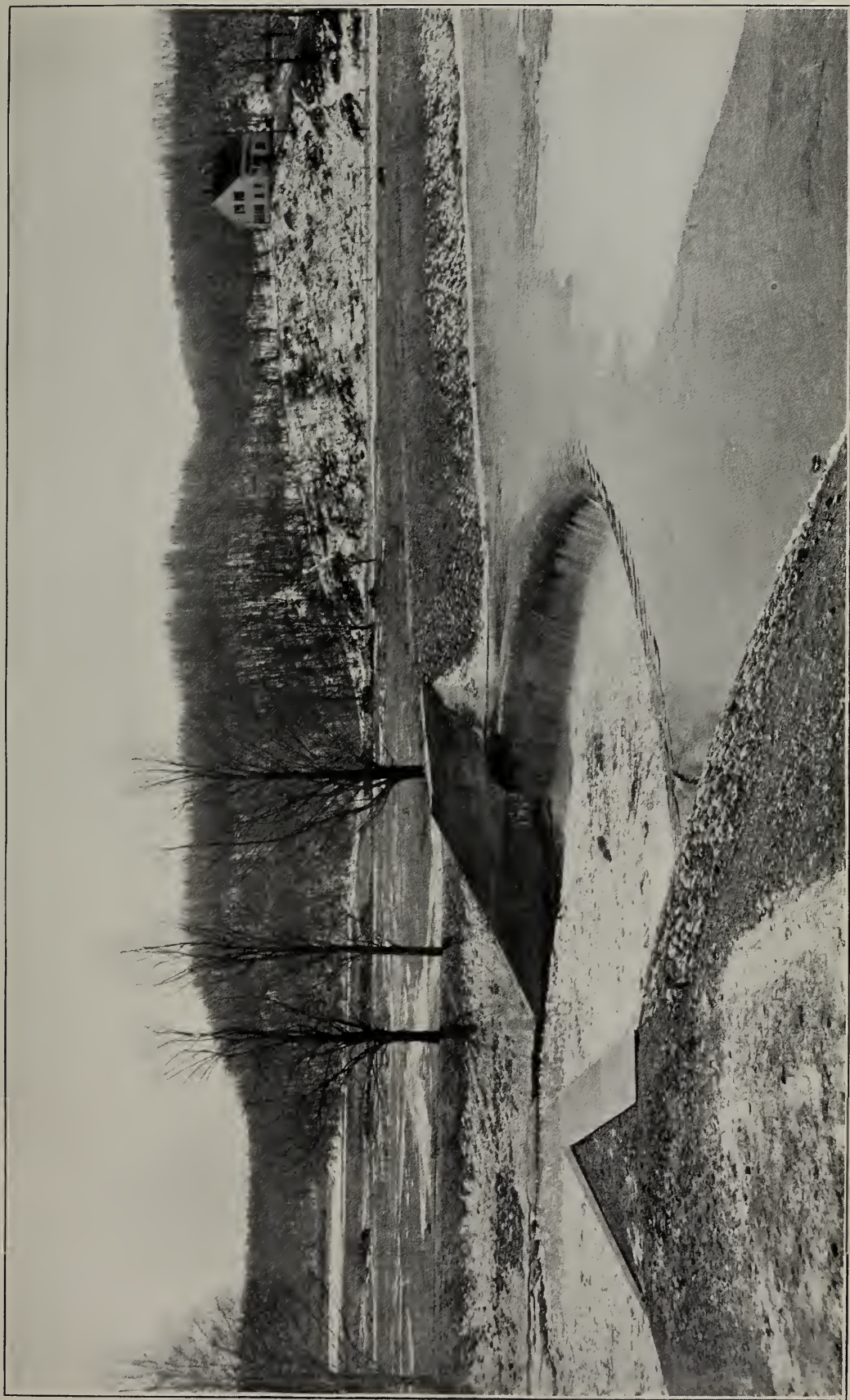
A considerable portion of the bottom of the reservoir near the upper end has been graded to secure proper drainage; the margins of the reservoir near the Worcester Street crossing have been graded, and numerous cellar holes have been filled and covered with soil.

Work under this contract was completed on November 11, excepting the removal of a few small buildings and of the contractor's plant.

The quantities of work done were as follows : —

	To December 31, 1904.	For the Year 1905.	Total.
Clearing and grubbing (acres), . . . . .	154	25	179
Soil excavation (cubic yards), . . . . .	1,193,208	80,412	1,273,620
Earth excavation (cubic yards), . . . . .	90,849	80,666	171,515
Rock excavation (cubic yards), . . . . .	16,943	280	17,203
Slope paving (cubic yards), . . . . .	18,992	3,193	22,185
Concrete (cubic yards), . . . . .	-	812	812





WACHUSETT RESERVOIR -- CIRCULAR DAM ON QUINEPOXET RIVER ABOVE OAKDALE.





The maximum force employed during the year has been 193 men and 69 horses, for the week ending May 20.

*Contract 283, McBride & Co.*

*Stillwater River Improvement, in West Boylston and Sterling; Date of Contract, May 15, 1905; Amount of Contract, \$28,181.69.*

The contract called for the improvement of that part of the reservoir along the Stillwater River, mostly above the Worcester, Nashua & Portland Division of the Boston & Maine Railroad. The work consisted mainly of clearing, grubbing and excavating soil from about 30 acres of the Wachusett Reservoir; also of deepening and draining shallow portions of the reservoir; of changing and enlarging the channel of the Stillwater River; of excavating additional material and gravel for the protection of slopes which will be exposed to the action of water; of building berms along the railroad and along the highway where it is close to the edge of the reservoir; and of paving the slopes of portions of railroad embankments and elsewhere where necessary.

The material removed has been transported to the place of disposal entirely by the use of carts.

The quantities of work done were as follows:—

Clearing and grubbing (acres), . . . . .	19
Earth excavation (cubic yards), . . . . .	120,491
Paving (cubic yards), . . . . .	768

Work under the contract was begun on May 24 and finished on November 11. The maximum force employed was 186 men and 60 horses, for the week ending June 17.

RELOCATION OF RAILROADS.

The principal part of the contract work upon the relocation of railroads was completed in 1903. As noted in previous reports, it was necessary to build a temporary location for the Central Massachusetts Railroad—a portion of the Boston & Maine Railroad—near the westerly end of the Wachusett Dam, in order not to interfere with the use of the travelling cableways which delivered materials for use in the masonry of the dam. Early in July it became feasible to limit the movement of the cableways sufficiently to permit the construc-

tion of the arch bridge over the waste channel. The grading of the permanent line of the railroad was finished about the middle of September, and shortly afterward employés of the Boston & Maine Railroad laid the track on the permanent location. The first train passed over this track on October 22.

Some paving has been placed along the Worcester, Nashua & Portland Division of the Boston & Maine Railroad; and the under-grade crossing near Oakdale, through which the contractor for Section 10 of the reservoir hauled soil, has been filled. Additional gravel has also been placed in the berms along the Worcester, Nashua & Portland Division and the Central Massachusetts Railroad near Oakdale.

The only day-labor work in connection with the relocation of the railroads has been the building of the false-work for the arch across the waste channel.

*Contract 195-A (245), McArthur Brothers Company.*

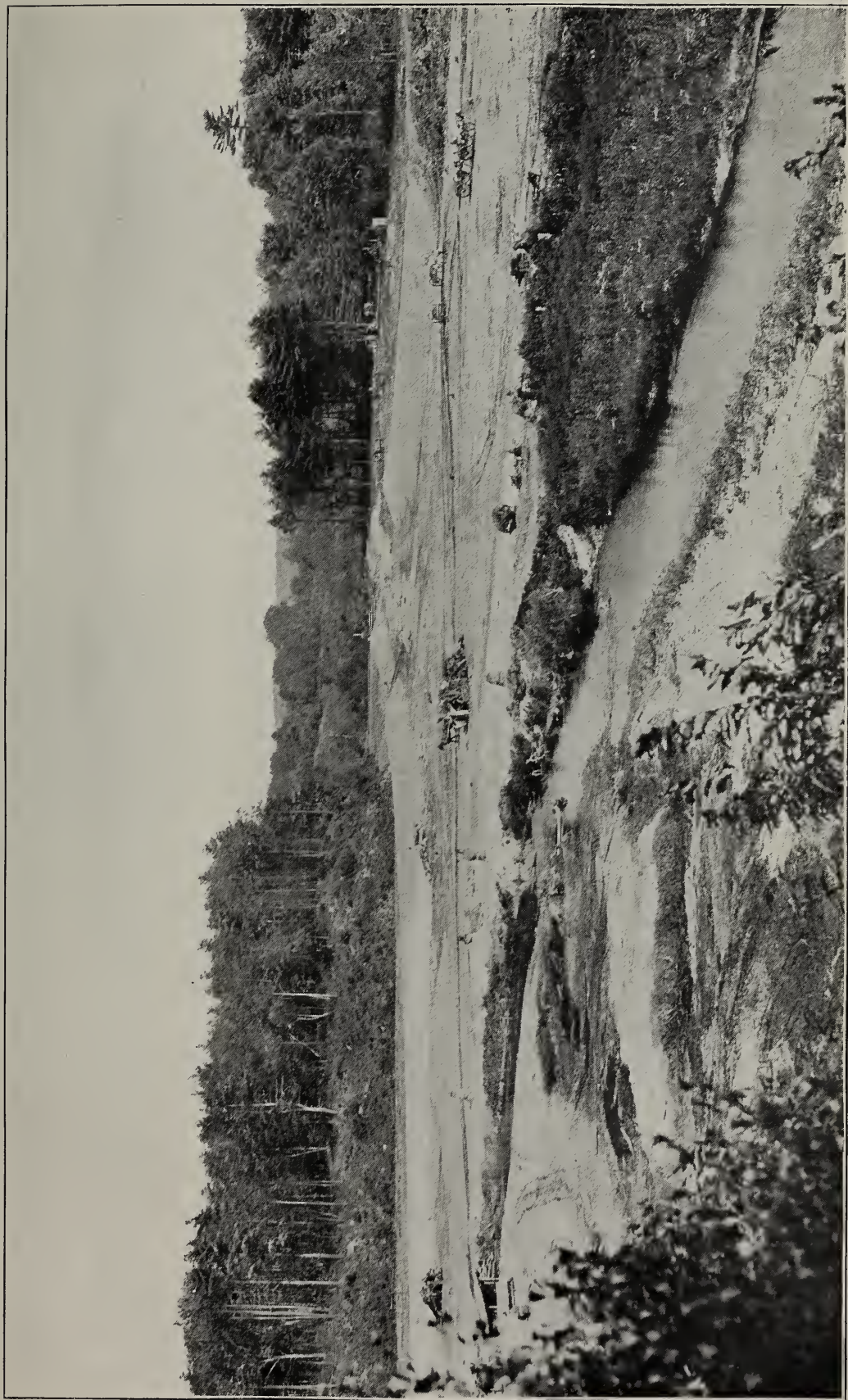
*Section 2 of the Relocation of the Central Massachusetts Railroad, in Clinton.*

On April 18, 1902, a contract was made with the McArthur Brothers Company for the construction of what is known as Section 2 of the Relocation of the Central Massachusetts Railroad. All of the work under this contract was completed in 1903, except the construction of a short length of permanent line of railroad in place of the temporary line necessarily used during the construction of the dam. The work included the construction of a masonry arch bridge to carry the railroad over the waste channel, the construction of short lengths of embankment on either side of the bridge, and the removal of the embankment of the temporary line.

The contractor began the work of laying masonry at the arch bridge on July 5, and completed the embankment of the permanent line about the middle of September. On October 23, immediately after the trains of the Boston & Maine Railroad began to run over the permanent line, work was begun on the removal of the embankment of the temporary line, and at the end of the year this work was practically completed.

The quantities of work done were as follows:—





WACHUSETT RESERVOIR — IMPROVEMENT OF STILLWATER RIVER CHANNEL.



	To December 31, 1904.	In 1905.	Total.
Earth excavation (cubic yards), . . . . .	25,500	16,200	41,700
Rock excavation (cubic yards), . . . . .	55,500	306	55,806
Tunnel excavation (cubic yards), . . . . .	18,800	-	18,800
Rubble stone masonry (cubic yards), . . . . .	-	920	920
Concrete masonry not in tunnel (cubic yards), . . . .	2,120	170	2,290
Concrete masonry in tunnel (cubic yards), . . . . .	2,360	-	2,360
Dimension stone masonry (cubic yards), . . . . .	740	385	1,125
Dry paving (cubic yards), . . . . .	140	-	140

The maximum force employed during 1905 has been 63 men and 30 horses, for the week ending November 18.

#### IMPROVING WACHUSETT WATERSHED.

Paved ditches with board bottoms, having an aggregate length of 2,875 feet, have been built to drain the swampy ground below the South Dike and the deeper part of the pit from which sand was obtained for the construction of the masonry of the Wachusett Dam. The maximum force employed on this work has been 26 men and 4 horses, for the week ending November 25.

A ditch about 1,870 feet long has been dug to drain swampy land near the Lamson nursery. The dams in Holden at the Canada and Unionville mill-ponds and at Day's Mill have been repaired. Considerable other work has been done by day-labor forces in constructing filter-beds, cesspools and privy vaults.

#### FORESTRY.

The work of cutting out fruit, mature and undesirable trees preparatory to planting has been done over about 175 acres. The fire guard 40 feet wide along the margins of the land purchased by the Board has been extended through timber land for about half a mile near Oakdale. An area of 101 acres was planted between April 15 and May 13, and of 147 acres between August 26 and October 14, largely with seedlings from the nurseries. Of the above, about 67 acres were in heavy grass land, where four-year-old white pine seedlings were planted in rows 6 feet apart each way; the remaining 181 acres were pasture and sprout land, which were planted



with three-year-old white pine seedlings, set at intervals of 10 feet, with sugar maple, hickory, chestnut, locust or oak planted between for fillers, where a suitable filler did not exist. In doing this work the following seedlings from the nurseries of the Board have been used: 163,600 pine, 106,300 maple, 9,800 chestnut, 3,200 locust, 10,000 oak, also 3 bushels of hickory nuts. The cost of taking the trees from the nursery and setting them in the ground has been \$4.95 per thousand trees, or \$5.55 per acre.

The following table gives information regarding land belonging to the Board above the flow-line of the reservoir. Outlying land and land along the Quinepoxet River above the road which formerly crossed the river to the Harris Mills is not included in this tabulation.

	Acres.
Area of land which was forested when acquired, . . . . .	1,431
Area which has been planted with trees, . . . . .	937
Area to be planted with trees, . . . . .	483
Area open and which will probably not be planted, . . . . .	300
Area of marginal strip along shores of reservoir, . . . . .	197
<hr/>	
Total area belonging to the Board, . . . . .	3,348

Four-year-old white pine seedlings have been planted at intervals of 40 feet along both sides of a public road near the North Dike for a distance of 1½ mile; and where trees planted along highways in previous years have died, they have been replaced for a distance of about 12½ miles. Two and three year old white pine seedlings and three-year-old arbor vitæ seedlings have been planted along 12½ miles of the reservoir margin; and where trees planted in previous years have died, they have been replaced for about the same distance. An additional row of arbor vitæ has also been planted along about 20 miles of the reservoir margin.

The total length of the flow-line of the reservoir, including 1.2 miles around Cemetery Island, is 38.2 miles. Arbor vitæ and white pine seedlings have been planted on the marginal strip along 27 miles of the flow-line. Along the dikes, highways and railroads, for a distance of 5.7 miles, trees will not be planted; and there remain about 5.5 miles of the marginal strip to plant with trees.

The necessary care has been given to the Flagg and Lamson nurseries during the year. There were transplanted from the nursery beds to the transplant rows at the Flagg nursery 52,200 white pines,

5,400 Scotch pines, 81,600 arbor vitæ and 12,300 Norway spruces. Besides the above stock in transplant rows, this nursery contains 494,000 white pines, 2,000 Scotch pines, 38,300 white spruces, 11,000 Douglas spruces, 8,800 Norway spruces, 127,000 arbor vitæ and 8,400 birches, hemlocks, larches, and tamaracks in seed beds. At the Lamson nursery there are 22,500 maples, 3,900 walnuts, 6,200 oaks, 2,400 ashes, and 15,800 locusts, and about 2 bushels of chestnuts, which have been laid away in sand preparatory to planting directly in the field next spring.

#### ENGINEERING.

In addition to the engineering work already enumerated and that necessarily connected with the supervision of the contract and day-labor work in progress, the engineering force of the Dam and Reservoir Department has performed the following work. Plans, specifications and estimates have been prepared for the construction of a new highway on the southerly side of the reservoir, between Oakdale and West Boylston, and for the treatment of that part of the reservoir lying along the Stillwater River. Elevations of the bottom of the reservoir, taken after the completion of the excavation, have been entered on the record sheets, and contour lines have been drawn covering an area of 920 acres, making a total of 3,420 acres covered by these final records at the end of the year. From these record sheets tables have been prepared showing the capacity of the reservoir at each tenth of a foot between elevations 325 and 370. Surveys have been in progress of the marginal line of the watershed, and the line has been surveyed for a distance of  $38\frac{1}{2}$  miles. The total distance around the margin of the watershed is about 69 miles. This survey has been connected with the system of co-ordinates of the Wachusett Reservoir by triangulation. Surveys and studies have been made for filter-beds for filtering the water of a brook which drains the village of Sterling, and much other minor engineering work has been done in connection with the settlement of claims and for other purposes.

#### CEMENT TESTS.

The usual tables of tests of cements used in the dam and other works at the Wachusett Reservoir, and in the Weston Aqueduct, may be found in Appendix No. 2.

**SUDBURY AND DISTRIBUTION DEPARTMENTS.**

DEXTER BRACKETT, *Department Engineer.*

The only actual work done in these departments chargeable to construction was the setting of a Venturi meter and the laying of a few lengths of 48-inch pipe at the low-service pumping station at Chestnut Hill. Studies and estimates have been made for new pumping machinery and a new pumping station in Arlington to replace the temporary plant which was installed in 1899. On October 28 a contract was made with the Allis-Chalmers Company of Milwaukee, Wis., for furnishing and installing during the coming year a horizontal high-duty pumping engine, capable of raising 1,500,000 gallons per twenty-four hours to a height of 300 feet. A considerable part of the time of the department engineer and his assistants has been spent upon matters connected with the suit brought by the cities of Malden, Medford and Melrose for damages on account of the taking of Spot Pond, and in the preparation of record plans of work done in previous years.

**OFFICE FORCE.**

FRANK T. DANIELS, *Principal Office Assistant until December 23*; BENJAMIN F. HANCOX, Jr., *Assistant in Charge of Drafting Department since December 23*; SAMUEL E. KILLAM, *Office Assistant.*

The following is a statement of the more important work upon which the drafting department has been engaged during the year.

For the Wachusett Reservoir a drawing was made showing the paving for the North Dike, and one showing the location of the stone masonry railroad bridge over the waste channel. For the Wachusett Dam there have been made grading plans for the hillside slopes and for the Boylston Street approach; detail drawings of steelwork for the upper gate-chamber and of steel re-enforcement for the granolithic surface of the dam, abutment, upper gate-chamber and bastion; detail drawings of stone curbing and of iron fence and gates for the Boylston Street approach; drawings for a granite balustrade to surmount the dam, which was not adopted; and detail drawings of the adopted design for a fence, consisting of cast brass posts and rails of seamless drawn brass tubing. Studies have been made for bronze tablets and for a fountain at the pool below the dam.

Detail drawings, with specifications, were made for a dwelling house for the foreman at the Weston Reservoir. Forty-three record



plans of structures on the Weston Aqueduct have been made, also 16 record drawings of work connected with the relocation of the Central Massachusetts Railroad. Working drawings were made for steel manhole covers and granite manhole curbing for use on the Sudbury and Cochituate aqueducts, also record drawings showing changes and repairs at Beaver Dam Brook culvert and Waban Valley bridge. The whole number of finished drawings completed during the year was 134.

During the year drawings pertaining to the works acquired from the city of Boston have been transferred to this department from the City Engineer's department. These plans, about 1,300 in number, have been examined, rearranged and indexed.

The force employed in the drafting department numbered 8 for the first month, 7 for the succeeding seven months and 6 for the last four months.

Samuel E. Killam has had charge of the general office, where the work is of a varied character, such as making miscellaneous investigations and computations, procuring supplies and making blue-prints. Mr. Killam has also had general charge of the photographic work.

#### ACCIDENTS.

No fatal accidents have occurred during the year.

#### MAINTENANCE.

(This report has been compiled from reports prepared by the engineers in charge of the various departments of the works.)

#### RAINFALL AND YIELD.

The total rainfall for the year on the Sudbury watershed has been 42.31 inches, or 3.78 inches below the average, the deficiency occurring in the months of February, March, April and May, during which time the rainfall was 9.38 inches, or 6.29 inches below the average. As a result of the small rainfall at the season of the year when the greatest percentage is collectible in the reservoirs, the yield of both the Sudbury and Wachusett watersheds has been low, that of the Sudbury watershed being 26 per cent. below the average of the preceding thirty years, and that of the Wachusett watershed 27 per cent. below the average of the preceding eight years during which records have been kept.

Statistics relating to rainfall and yield of watersheds may be found in Appendix No. 3, tables Nos. 1 to 11.

STORAGE RESERVOIRS.

The quantity of water stored in all of the storage reservoirs on January 1, 1905, was 15,638,100,000 gallons. Rains early in January, aggregating about 3.5 inches, caused an increase of about 4,000,000,000 gallons in the quantity stored; but on account of the low rainfall and cold weather after that time there was a lowering of the reservoirs from the middle of January until March 8. During March and April the reservoirs were filling, reaching the maximum for the year of 33,708,200,000 gallons, on May 1. From May 1 to September 3 there was an almost continual loss of storage, and on the latter date the reservoirs contained 26,758,900,000 gallons. On September 2, 3 and 4 about 6 inches of rain fell, causing an increase of 4,000,000,000 gallons in the quantity of water stored. From the middle of September until the end of November the storage decreased, but did not fall quite to the point reached early in September. During December the reservoirs were filling, and at the end of the year the quantity stored was 28,971,900,000 gallons.

The following table gives the quantity of water stored in the storage reservoirs at the beginning of each month : —

Quantity of Water stored in Wachusett Reservoir, and in Reservoirs on Sudbury and Cochituate Watersheds, at the Beginning of Each Month.

DATE.	In Wachusett Reservoir (Gallons).	In Sudbury Reservoir and Framingham Reservoir No. 3 (Gallons).	In All Other Storage Reservoirs (Gallons).	Total (Gallons).
<b>1905.</b>				
January 1, . . . . .	4,409,600,000	7,912,500,000	3,316,000,000	15,638,100,000
February 1, . . . . .	7,549,200,000	6,937,900,000	4,432,900,000	18,920,000,000
March 1, . . . . .	5,800,700,000	7,011,700,000	4,016,700,000	16,829,100,000
April 1, . . . . .	15,371,300,000	7,329,600,000	5,715,300,000	28,416,200,000
May 1, . . . . .	20,498,900,000	6,678,900,000	6,530,400,000	33,708,200,000
June 1, . . . . .	18,350,600,000	6,951,900,000	6,916,700,000	32,219,200,000
July 1, . . . . .	16,582,300,000	7,853,200,000	7,087,000,000	31,522,500,000
August 1, . . . . .	14,951,000,000	7,993,200,000	6,489,400,000	29,433,600,000
September 1, . . . . .	13,774,300,000	7,877,600,000	5,286,900,000	26,938,800,000
October 1, . . . . .	16,208,700,000	7,916,300,000	6,106,600,000	30,231,600,000
November 1, . . . . .	15,057,100,000	7,847,800,000	5,178,700,000	28,083,600,000
December 1, . . . . .	14,628,900,000	7,772,500,000	4,662,000,000	27,063,400,000
<b>1906.</b>				
January 1, . . . . .	17,115,300,000	6,831,300,000	5,025,300,000	28,971,900,000

*Wachusett Reservoir.* — At the beginning of the year the water in this reservoir was at elevation 317, or 33 feet above the bottom of the 48-inch outlet pipes, and the reservoir contained 4,409,600,000 gallons of water. On account of the small rainfall during the first five months of the year the yield of the streams entering the reservoir was very much below the average. The highest elevation reached during the year was 349.63, on April 28, when the reservoir contained 20,697,900,000 gallons. From May 1 until September 3, and from September 15 to December 6, water was drawn from the reservoir practically continuously for the supply of the Metropolitan District. At the end of the year the water stood at elevation 344.06, and the reservoir contained 17,115,300,000 gallons. The only water discharged from the reservoir into the river below the dam was that required to be so discharged for the use of the Lancaster Mills and others. The average quantity as measured at the gaging station below the Lancaster Mills was 2,309,000 gallons per day.

*Sudbury Reservoir.* — At the beginning of the year the water in this reservoir stood at elevation 259.18, or .18 of a foot above the stone crest of the dam. The lowest point during the year was reached on February 14, when it stood at elevation 255.82. During March, April and May the water stood from 1 to 3 feet below the crest of the dam. Early in June it was raised to the level of the crest, and from June 10 until December 17 water was running almost continuously over the crest of the dam, the reservoir being kept full by a flow from the Wachusett Reservoir. On December 16 the flow from the Wachusett Reservoir was shut off, and at the end of the year the Sudbury Reservoir had fallen about 2 feet.

A gravel driveway has been built from the head-house of the Weston Aqueduct to the store-house at the northerly end of the dam, the loam removed in constructing the driveway being used to cover an unsightly rock dump below the dam. A large number of pine trees were set out on the grounds, 500 chestnut posts cut for use on the works, joints on the overflow of the dam repointed, a new capstone and a short piece of coping set on the retaining wall of the channel below the dam, and a new cesspool built for the house at the dam occupied by the foreman.

The *Marlborough Brook filter-beds* have been in use throughout the year, and have filtered all the water received from the brook



except for a few hours on January 7. The beds were cleaned in the latter part of June and early in July, and the natural beds were again cleaned in November. Cracks in the concrete channel dams were cut out and pointed, and a new connection with concrete walls fitted with stop-planks was made between beds 25 and 26. A 12-inch Akron pipe 718 feet long has been laid between a manhole on the Marlborough sewer and filter-bed No. 20 of the Marlborough Brook filter-beds. By means of valves set in the manholes the flow in the sewer can now be diverted on to the filter-beds, in case the storage reservoir and filter-bed on Farm Road should be at any time in danger of overflowing. During the past year diluted sewage flowed on to this filter-bed on March 25, 26 and 27, April 6, September 3, 4, 5, 6 and 7.

Eight new stone bounds were set to define property lines along the Marlborough Brook, the brook was cleaned, and adjoining property owners who had encroached upon the property of the Board by depositing ashes and other rubbish were required to remove the same.

*Framingham Reservoir No. 3.* — This reservoir was kept nearly full of water during the year, water for that purpose having been drawn from the Sudbury Reservoir when required. At the end of the year the water stood about 3 feet below the crest of the dam. The ceiling of the gate-house and the exterior of the shed and boat-house at the dam were painted.

*Framingham Reservoir No. 2.* — This reservoir was kept practically full throughout the year, the lowest point reached being about 3 feet below the crest of the dam, on October 3. During the previous week water was wasted preparatory to filling the reservoir with water of better quality from the Ashland and Hopkinton reservoirs. Water was drawn from the reservoir for the supply of the Metropolitan District for a longer period and in greater quantity than at any time since 1898. Water was drawn from the reservoir to Lake Cochituate on December 4 and 5. The ceiling of the gate-house, the exterior of the shed and boat-house near the dam and the fence on both sides of Fountain Street were painted, 5 land bounds were set, a granolithic cap placed on the gate-house chimney, and the joints in the masonry of the chimney repointed.

*Framingham Reservoir No. 1.* — This reservoir was full and water wasted over the dam for the greater portion of the time from the

beginning of the year until the latter part of June. During the last half of the year but little water was wasted. Water was drawn from this reservoir and discharged into Lake Cochituate on May 5 and 6, during parts of nine days from September 4 to 15, inclusive, and on four days from December 1 to 5. The gate-house ceiling was painted and the chimney repaired in the same manner as at Reservoirs Nos. 2 and 3.

*Ashland Reservoir.* — At the beginning of the year the water in this reservoir was 31.34 feet below high water. It rose to the level of the stone crest on May 29, and the reservoir remained practically full until early in July. Water was drawn from the reservoir in varying quantities during each of the last six months of the year. On September 3 its surface was at elevation 216.86, or 8.35 feet below high water, which was the lowest point reached during the last half of the year. It was 4.3 feet below high water on January 1, 1906. The lower gate at the gate-house, through which there had been a small leakage for a number of years, was repaired early in the year. The exterior of the gate-keeper's house and the interior walls of the gate-house have been painted, and the walk on the dam, 1,800 feet in length, resurfaced with gravel.

*Hopkinton Reservoir.* — This reservoir was 31.48 feet below high water at the beginning of the year. On June 29 it was at elevation 303.92, or 1.08 feet below high water, which was the highest point reached during the year. The draft from the reservoir in the last half of the year lowered the surface to elevation 293, or 12 feet below high water, on November 29. At the end of the year it had risen to elevation 295.74. About four-fifths of the water drawn from the reservoir was filtered through the beds below the dam. One of the gates at the dam, through which there was a small leakage, was repaired. A survey was made and 14 stone bounds set on the boundary line of land just below the dam formerly belonging to William F. Ellis and Levi F. Hollis. The filter-beds were cleaned as usual, and the southerly half of the roof of the gate-keeper's house was shingled.

*Whitehall Reservoir.* — Water was drawn from this reservoir in January, February and March, lowering it from elevation 337.29 on January 10 to elevation 333.27 on March 9. The outlet gate was then closed and the reservoir filled slowly, but did not rise to high-water mark during the year, although no water was drawn from the reservoir from March 9 until December 16, when it stood at eleva-



tion 337.83, or 2.07 feet below the extreme level to which the water can be raised by the new dam. At the end of the year it had fallen to elevation 337.27.

*Farm Pond.* — The water in this pond was kept from about high water to 1 foot below during the year. It was twice partially filled with water drawn from Framingham Reservoir No. 1, once in May and again in November. No water was drawn from the pond for the use of the Metropolitan District, and none was wasted into the Sudbury River. The paving on the slopes of the embankment of the aqueduct where it passes through the pond has been relaid at points where it had settled or been thrown out of position by the action of the waves and ice. A galvanized-iron cap was placed on the gate-house chimney, and the chimney repointed.

*Lake Cochituate.* — At the beginning of the year the water in the lake was 4.52 feet below high water; on March 27 the lake was full, and remained at or near high-water mark until the middle of July, after which date the draft for the supply of the District lowered its surface to 140.35 on September 3. The heavy rainfall at this time, and water turned into the lake from Framingham Reservoir No. 1, raised the lake about 3 feet; but after the middle of September there was a gradual drop in its surface, and on November 29 it was 6.46 feet below high water, the lowest point reached during the year. During the first week in December water was turned into the lake from Framingham Reservoirs Nos. 1 and 2; and on January 1, 1906, it was 5.68 feet below high water.

The joints in the stone masonry of the outlet dam were cut out and repointed, the joints in the horizontal surfaces being pointed with elastic cement and in the vertical joints with Portland cement. A new 1-inch cement-lined water pipe, 281 feet long, was laid between the foreman's house and the barn, the foreman's house resingled, and the driveway from the street to the barn resurfaced with gravel.

The channel of Course Brook, through which the water flows when running from the Sudbury Aqueduct into the lake, was cleaned for a distance of about 2,400 feet, and the brush cut on the land adjacent to the brook. Twenty-five stone bounds were set to define property lines on the east shore of the lake.

At the beginning of the year Dudley Pond was 3.34 feet below high water. The highest elevation was 2.13 feet below high water,



in the latter part of April; and the lowest 4.14 feet below high water, on November 27. From July 21 to 26, inclusive, a total quantity of 20,800,000 gallons was discharged from the pond into Lake Cochituate.

The surface of Dug Pond varied between .69 of a foot above and 2.91 feet below the invert of the 18-inch overflow pipe.

The Pegan Brook filter-beds were in use on 202 days during the year. All of the brook water was filtered with the exception of small quantities which overflowed on parts of 6 days, and all of the water from the intercepting ditch except on parts of 6 days. The total quantity of water pumped during the year was 235,317,000 gallons, of which 158,020,000 gallons were from Pegan Brook and 77,297,000 gallons from the intercepting ditch. The total quantity of coal consumed was 150,068 pounds, indicating 1,568 gallons of water pumped per pound of coal. The cost of operating the pumping station and caring for the filter-beds and grounds was \$2,536.17, making the cost per million gallons pumped \$10.78. The filter-beds have been cleaned several times when necessary, also the ditches in the upper portion of the Pegan Brook receiving reservoir, and the deposit removed from the bottom of the settling reservoir for the drainage ditch. This reservoir had not been cleaned since it was built, two years ago, and the deposit was 4 inches in depth. The pumping machinery was painted, and a number of pine trees set out along the drive leading from the street to the station.

#### SOURCES FROM WHICH WATER HAS BEEN TAKEN.

An average of 71,877,000 gallons per day was drawn from the Wachusett Reservoir through the Wachusett Aqueduct into the Sudbury Reservoir. An average of 30,742,000 gallons per day was drawn from the Sudbury Reservoir through the Weston Aqueduct into the distribution system of the Metropolitan District. From Framingham Reservoir No. 3 an average of 63,539,000 gallons per day, and from Framingham Reservoirs Nos. 1 and 2 an average of 11,845,000 gallons per day, was drawn through the Sudbury Aqueduct to Chestnut Hill Reservoir. An average of 15,313,000 gallons per day was drawn from Lake Cochituate through the Cochituate Aqueduct to Chestnut Hill Reservoir. The Spot Pond drainage area furnished 310,000 gallons per day.

## AQUEDUCTS.

The *Wachusett Aqueduct* has been in use 266 days during the year. It was thoroughly cleaned between December 6 and 11. It was also examined at this time, and was found to be in excellent condition. The usual work of maintenance along the line of the aqueduct has been performed, and the grounds and appurtenances are in excellent condition.

The *Sudbury Aqueduct* was in service on 359 days during the year. The masonry portion of the aqueduct was cleaned on April 11 to 14 and April 19 to 22. The repairs made on the Waban Bridge in 1904 reduced the leakage from the aqueduct to a very small amount; but during the extreme cold weather in January and February ice formed in the open spaces under the aqueduct to such an extent that it became necessary to operate the steam plant for about a month. While the aqueduct was emptied for cleaning, cracks in the invert were pointed from station  $284 + 88$  to  $285 + 60$ , and from station  $642 + 24$  to  $644 + 47$ ; and in the arch from station  $284 + 95$  to  $285 + 65$ , and from station  $642 + 22$  to  $644 + 70$ .

When the aqueduct was constructed, manhole openings 3 feet square were left in the top at intervals of about 1,500 feet. These manhole openings were built with a granite coping and cover which was covered with about 1 foot of earth; but, for convenience in obtaining access to the aqueduct, wooden curbings and covers have been in use for several years on a number of these manholes. During the past year the stone copings on 18 of the manholes have been raised to the level of the ground, and iron covers placed over the openings.

The ironwork in the roof, as well as other ironwork in the Farm Pond gate-house, was painted, also a small shed near the gate-house, and the storehouse on the line of the aqueduct at South Framingham.

The city of Newton laid an 8-inch sewer over the aqueduct at Gibbs Street, Newton Center, using for the crossing 72 feet of cast-iron pipe laid with leaded joints.

The culvert which passes under the aqueduct near Grant Avenue in Newton has been deepened and enlarged by removing paving and underlying gravel down to the plank floor which forms the foundation for the sidewalls of the culvert. On the floor was laid a 2-inch layer of concrete, in which was embedded expanded metal secured to the floor with composition nails. The depth of the culvert was increased from 3.8 feet to 6 feet.

The *Cochituate Aqueduct* was in use 249 days. The interior of the aqueduct, with the exception of the siphon pipes, was cleaned on May 10 to 13, inclusive. The iron gratings and all ironwork below high-water level at the several waste-weirs have been painted, and the brass work in connection with the gate stems cleaned. Masonry curbings with iron covers have been built on 13 manholes, replacing wooden curbings which had been previously used. The surveys for locating the aqueduct and determining the position of property bounds have been continued, and 42 land bounds and 41 alignment bounds have been set.

The *Weston Aqueduct* was in use 302 days. The flow was stopped nearly all of the time from the first of the year until February 8, also from March 3 to 13, during which time men were employed in cutting out and repointing cracks in the aqueduct masonry. While the aqueduct was being repaired it was cleaned for its entire length. The work of cutting out and pointing fine transverse cracks, which was started at the very last part of the previous year, was entirely completed in March. The number of cracks cut out and pointed was 724. In connection with this work, 319 1-inch and 1½-inch pipes were built into the masonry, and through most of the pipes cement grout was forced until all interstices were filled.

The barn at the White place, in Saxonville, was repaired. A portion of the steep bank at the portal to tunnel No. 1 at the back of the head-house was sodded, and the remainder of the bank will be sodded in the spring if that which has already been placed remains in position during the winter. Sand banks near siphon chamber No. 2 were sloped and a large number of pine trees set out. Trees have also been set on the slopes of the sand banks west of siphon chamber No. 2, and in the borrow pits between siphon chambers Nos. 2 and 3. Two broad dikes with very flat slopes were built on the Bowditch estate in Framingham, to prevent the water from Baiting Brook overflowing and passing through a culvert under the aqueduct near Millwood Street. One of these dikes was about 180 feet long, with an extreme height of 2.1 feet; and the other 125 feet long, with a height of 1.7 feet. Two screens have been built and the frames set in the head-house of the aqueduct. A current meter apparatus was installed in the gaging chamber early in February, and during the year a large number of current meter measurements have been made for determining the flow of the aqueduct at different depths.



## PUMPING STATIONS.

Seventy-five per cent. of all the water supplied to the Metropolitan Water District has been pumped at the two stations at Chestnut Hill Reservoir; the remainder was delivered by gravity. The total quantity pumped at all of the stations during the year was 35,986,-230,000 gallons, or 1,024,140,000 gallons more than during the preceding year. The cost of operating the stations was \$93,752.58, equivalent to \$2.605 per million gallons pumped, which was 1 cent per million gallons less than the corresponding cost during the year 1904.

The cost per gross ton of fuel used at the Chestnut Hill high-service station was the same as in 1904, at the Chestnut Hill low-service station \$0.28 less, and at the Spot Pond station \$0.04 less, than during the preceding year.

Thirty-three tests have been made to determine the viscosity, specific gravity and burning point of oil used at the several stations, and 28 tests were made to determine the calorific value of the several lots of coal used.

Coal for use at the several stations has been purchased as follows:—

	GROSS TONS.					Price per Gross Ton.
	Chestnut Hill High- service Station.	Chestnut Hill Low- service Station.	Spot Pond Station.	West Roxbury Station.	Arling- ton Station.	
Bay State Fuel Company, bituminous, .	98.44	-	-	-	-	\$5 28
George W. Bailey Company, bituminous,	90.85	-	-	-	-	4 73
Metropolitan Coal Company, bituminous,	391.57	-	-	-	-	4 50
Dartmouth Coal Company, bituminous, .	-	578.28	-	-	-	4 37
Metropolitan Coal Company, bituminous,	-	418.52	-	-	-	4 35
Dartmouth Coal Company, bituminous, .	891.96	-	-	-	-	4 30
Merchants Coal Company, bituminous, .	2,175.09	-	-	-	-	4 12
Merchants Coal Company, bituminous, .	-	1,475.53	-	-	-	3 98
E. B. Townsend, buckwheat anthracite, .	18.10	-	-	-	-	3 58
E. B. Townsend, buckwheat anthracite, .	-	92.25	-	-	-	3 26
Dartmouth Coal Company, buckwheat anthracite,	80.20	-	-	-	-	3 11
W. M. W. Spring, buckwheat anthracite,	435.80	-	-	-	-	3 11
C. W. Clafin & Co., buckwheat anthra- cite.	71.50	-	-	-	-	3 02
W. M. W. Spring, buckwheat anthracite,	-	555.92	-	-	-	2 89
Dartmouth Coal Company, buckwheat anthracite.	-	114.21	-	-	-	2 85

	GROSS TONS.					Price per Gross Ton.
	Chestnut Hill High- service Station.	Chestnut Hill Low- service Station.	Spot Pond Station.	West Roxbury Station.	Arling- ton Station.	
C. W. Claflin & Co., buckwheat anthra- cite.	-	394.10	-	-	-	\$2 78
Bay State Fuel Company, screenings, .	552.17	-	-	-	-	2 52
Malden Coal Company, bituminous, .	-	-	493.25	-	-	4 38
Locke Coal Company, screenings, . .	-	-	442.57	-	-	24
D. J. Cutter & Co., anthracite, . . .	-	-	-	301.62	-	7 28
Metropolitan Coal Company, anthracite,	-	-	-	53.57	-	7 17
Peirce & Winn Company, bituminous, .	-	-	-	-	385.89	\$4 51 to 4 98
Peirce & Winn Company, screenings, .	-	-	-	-	197.58	2 24
Total gross tons, bituminous, . . .	3,647.91	2,472.33	493.25	-	385.89	-
Total gross tons, anthracite, . . .	605.60 <sup>1</sup>	1,156.48 <sup>1</sup>	-	355.19	-	-
Total gross tons, anthracite screen- ings.	552.17	-	442.57	-	197.58	-
Average price per gross ton, bitu- minous.	\$4 25	\$4 14	\$4 38	-	\$4 59	-
Average price per gross ton, anthra- cite.	3 11 <sup>1</sup>	2 87 <sup>1</sup>	-	\$7 26	-	-
Average price per gross ton, anthra- cite screenings.	2 52	-	2 24	-	2 24	-

<sup>1</sup> Buckwheat.

*Chestnut Hill High-service Station.*

The water used in the high-service district of Boston, the city of Quincy and the towns of Watertown, Belmont and Milton, was pumped at this station.

The following are the statistics relating to the operations at this station : —

	Engines Nos. 1 and 2.	Englne No. 3.	Engine No. 4.	Totals for Station.
Total quantity pumped (million gallons), . . .	1,381.48	481.82	10,564.86	12,428.16
Daily average quantity pumped (gallons), . . .	3,785,000	1,320,000	28,945,000	34,050,000
Total coal used (pounds), . . . . .	1,985,452	424,881	8,505,184	10,915,517
Gallons pumped per pound of coal, . . . . .	695.80	1,134.01	1,242.17	1,138.58
Average head pumped against (feet), . . . . .	120.87	128.01	130.39	129.24
Cost of pumping : —				
Labor, . . . . .	\$4,700 79	\$648 93	\$10,477 87	\$15,827 59
Fuel, . . . . .	3,626 21	744 12	14,789 61	19,159 94
Repairs, . . . . .	573 95	640 30	584 08	1,798 33
Oil, waste and packing, . . . . .	196 99	27 19	439 08	663 26
Small supplies, . . . . .	213 57	29 48	476 03	719 08
Totals, . . . . .	\$9,311 51	\$2,090 02	\$26,766 67	\$38,168 20
Cost per million gallons pumped, . . . . .	\$6.740	\$4.338	\$2.534	\$3.071
Cost per million gallons raised 1 foot high, . . .	0.056	0.034	0.019	0.024

On account of an increase of over 9 per cent. in the quantity pumped, it has been necessary to operate the less economical machinery to a greater extent than during previous years. Notwithstanding this, the cost per million gallons pumped at the station shows no increase above that of the previous year.

The amount of repair work done at this station was considerably greater than during the previous year. The principal items were the repairs to the two Gaskill pumping engines, Nos. 1 and 2, installed in 1885. The water plungers of No. 1 engine were turned and new composition packing sleeves made, which greatly reduced the slip of the pumps. On November 8 the straps on the fork end of one of the main connecting rods of No. 2 engine broke, causing extensive damage to the right-hand engine. Two new rods of improved design are now being made by the Holly Manufacturing Company of Buffalo, N. Y., and the water plungers are being turned and new composition sleeves made by the Lockwood Manufacturing Company, who also did the work on the plungers of No. 1 pump. The work of installing the new parts, and of making other necessary repairs, is being done by the regular employ  s at the station, with some assistance from the Atlantic Works.

One of the lower Riedler valve seats in the pump of the No. 3 engine broke on June 28. Temporary repairs were made so that the engine could be used, and a new valve seat and spindle were made by the Lockwood Manufacturing Company, but have not yet been put in the pump.

A new Flather lathe was installed in the machine shop. A centrifugal waste cleaner was purchased for use at both the high and low service stations, and a considerable saving has been effected by its use. A new coal-handling platform was built, the derrick was altered and improved, and a new floor laid on the run-ways in the coal-house.

*Chestnut Hill Low-service Pumping Station.*

The quantity of water pumped at this station was 0.8 per cent. less than during the year 1904.

The following are the statistics relating to operations at this station : —

	Engines Nos. 5, 6 and 7.
Total quantity pumped (million gallons), . . . . .	20,104.86
Daily average quantity pumped (gallons), . . . . .	55,082,000
Total coal used (pounds), . . . . .	8,215,258
Gallons pumped per pound of coal, . . . . .	2,447.26
Average head pumped against (feet), . . . . .	50.81



Cost of pumping: —		Engines Nos. 5, 6 and 7.
Labor, . . . . .		\$15,157 44
Fuel, . . . . .		13,850 69
Repairs, . . . . .		1,555 05
Oil, waste and packing, . . . . .		638 37
Small supplies, . . . . .		648 61
Total for station, . . . . .		\$31,850 16
Cost per million gallons pumped, . . . . .		\$1.584
Cost per million gallons raised 1 foot high, . . . . .		0.031

The cost per million gallons pumped was \$0.087 less than for the year 1904. This was principally due to the decreased price of fuel and a reduction of 4.10 feet in the average head pumped against.

*Spot Pond Pumping Station.*

At this station engine No. 8 was operated from October 28 to November 24, while repairs were being made on engine No. 9. During the remainder of the year all the water was pumped with engine No. 9, the 20,000,000-gallon Holly engine.

The following are the statistics relating to operations at this station: —

	Engine No. 8.	Engine No. 9.	Totals for Station.
Total quantity pumped (million gallons), . . . . .	189.55	2,818.20	3,007.75
Daily average quantity pumped (gallons), . . . . .	519,000	7,721,000	8,240,000
Total coal used (pounds), . . . . .	190,381	2,374,510	2,564,891
Gallons pumped per pound of coal, . . . . .	995.64	1,186.86	1,172.66
Average head pumped against (feet), . . . . .	119.05	129.52	128.86
Cost of pumping:—			
Labor, . . . . .	\$719 23	\$5,879 25	\$6,598 48
Fuel, . . . . .	373 60	3,759 52	4,133 12
Repairs, . . . . .	63 89	522 22	586 11
Oil, waste and packing, . . . . .	24 80	202 70	227 50
Small supplies, . . . . .	35 76	292 32	328 08
Totals, . . . . .	\$1,217 28	\$10,656 01	\$11,873 29
Cost per million gallons pumped, . . . . .	\$6.422	\$3.781	\$3.948
Cost per million gallons raised 1 foot high, . . . . .	0.054	0.029	0.031

The cost per million gallons pumped was \$0.106 less than during the previous year, due to an increase in the quantity of

water pumped, without material increase in the expense of operation.

The low-pressure lower inlet valve gear on engine No. 9 was repaired, causing the engine to run more smoothly.

### *West Roxbury Pumping Station.*

At this station water was pumped for supplying the higher portions of West Roxbury and Milton.

The following are the statistics relating to operations at this station : —

Pumps operated 7,522 hours 30 minutes ; average, 21 hours per day.	
Daily average quantity of water pumped (gallons), . . . . .	636,000
Daily average quantity of coal consumed (pounds), . . . . .	2,184
Gallons pumped per pound of coal, . . . . .	291
Average lift in feet, . . . . .	136
Cost of pumping : —	
Labor, . . . . .	\$3,152 88
Fuel, . . . . .	2,591 27
Repairs and small supplies, . . . . .	329 53
Total for station, . . . . .	\$6,073 68
Cost per million gallons pumped, . . . . .	\$26.173
Cost per million gallons raised 1 foot high, . . . . .	0.192

The quantity of water pumped was 132,000 gallons per day, or 26.2 per cent. greater than during the year 1904. The increase in cost of operation was 14.3 per cent. The cost per million gallons pumped was \$2.626 less than during the previous year.

One of the 54-inch vertical boilers was repaired by putting in new tube sheets. The work was done by the Atlantic Works at a cost of \$169. A Westinghouse locomotive type air compressor was installed at this station, for use in filling the air chambers on the pumps.

### *Arlington Pumping Station.*

All water supplied to the town of Lexington and to the high-service district of Arlington was pumped at this station.

The following are the statistics relating to operations at this station : —

Pumps operated 8,755 hours 45 minutes ; average 24 hours per day.	
Daily average quantity of water pumped (gallons), . . . . .	585,000
Daily average quantity of coal consumed (pounds), . . . . .	3,564
Gallons pumped per pound of coal, . . . . .	164
Average lift in feet, . . . . .	282

Cost of pumping : —	
Labor, . . . . .	\$3,207 18
Fuel, . . . . .	2,326 20
Repairs and small supplies, . . . . .	253 87
Total for station, . . . . .	<u>\$5,787 25</u>
Cost per million gallons pumped, . . . . .	\$27.119
Cost per million gallons raised 1 foot high, . . . . .	0.096

The quantity pumped was 68,000 gallons per day, or 13.2 per cent. greater than during the year 1904. The cost per million gallons pumped was \$1.08 less, due to increase in the amount of water pumped, while the cost of operation did not increase in the same proportion.

On July 19 one of the water plunger rods on the Blake compound pump broke ; a new rod was obtained and the damage was repaired in a few hours.

The building was shingled and otherwise repaired.

CONSUMPTION OF WATER.

The daily average quantity of water consumed in the cities and towns supplied by the Metropolitan Water Works during the year 1905 was 118,398,000 gallons, equal to 131.2 gallons per inhabitant in the district supplied. In addition to the above, 269,170,000 gallons were supplied to the city of Cambridge, 4,000,000 gallons were supplied to the town of Wakefield, and 1,608,000 gallons were supplied to the United States Government Reservation on Peddock's Island, making a total so supplied of 274,778,000 gallons, equivalent to a daily average rate of 753,000 gallons.

The consumption in the several districts was as follows : —

	Gallons per Day.	Increase (Gallons per Day).
Southern low-service district, embracing the low-service district of Boston, with the exception of Charlestown and East Boston,	47,106,000	570,000 <sup>1</sup>
Northern low-service district, embracing the low-service districts of Somerville, Chelsea, Malden, Medford, Everett, Arlington, Charlestown and East Boston,	23,436,000	827,000
Southern high-service district, embracing the high-service districts of Boston, Quincy, Watertown, Belmont, and a portion of Milton,	33,409,000	2,799,000
Northern high-service district, embracing Melrose, Revere, Winthrop, Swampscott, Nahant and Stoneham, and the high-service districts of Somerville, Chelsea, Malden, Medford, Everett and East Boston,	8,226,000	233,000
Southern extra high-service district, embracing the highest portions of West Roxbury and Milton,	636,000	132,000
Northern extra high-service district, embracing Lexington and the highest portions of Arlington,	585,000	68,000
Totals, . . . . .	118,398,000	3,489,000

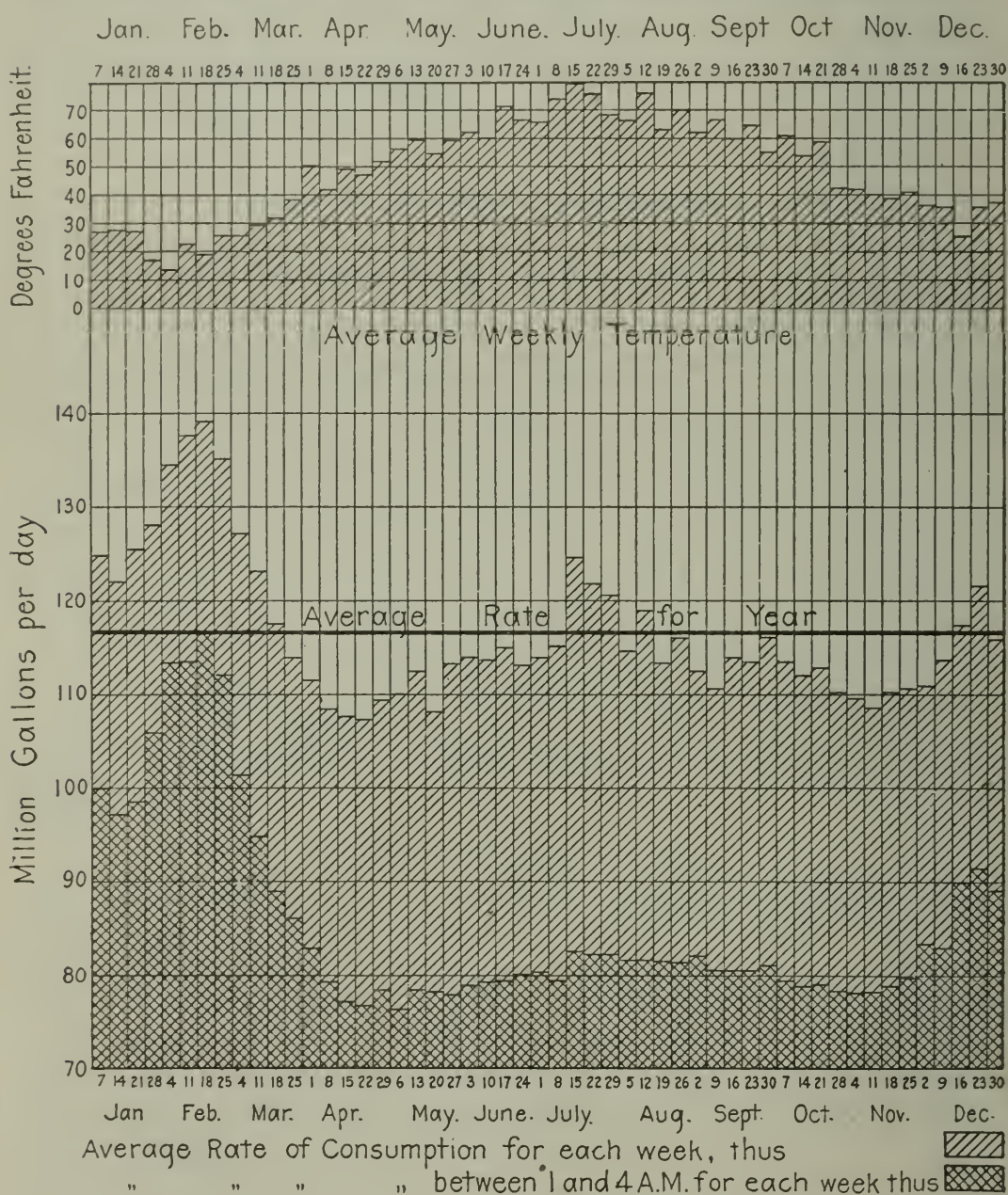
<sup>1</sup> Decrease.



The area of the several districts remains substantially the same as in 1904. The average daily rate of consumption for the past year has increased 3,489,000 gallons.

During the year continuous measurements have been made by means of Venturi meters of the water consumed in each city and town supplied from the Metropolitan Works. From these measurements can be determined the consumption of water at any hour of the day in any city or town; and in cases where the city or town is

*Average Rate of Consumption in Metropolitan Water District and Average Temperature of Air at Chestnut Hill Reservoir for Each Week during 1905.*



divided into low and high service districts, the rate of consumption in each of these districts can also be determined.

The diagram on the preceding page shows the average rate of consumption in the district supplied by the Metropolitan Works for each week during the year, also the rate of consumption between the hours of 1 and 4 A.M., and the average temperature of the air for the week. It will be noticed that the largest consumption of water occurred during the weeks when the temperature was lowest, and during the coldest weather the rate of consumption between the hours of 1 and 4 A.M. is abnormally high. This abnormally high night rate in cold weather, however, does not occur in cities and towns where water supplied to the consumers is metered.

A comparison of the diagram here given with the corresponding diagram for the year 1904 shows that half of the increase in the consumption of water over that of the previous year is attributable to the increase in the amount of leakage and waste as indicated by the consumption during the hours from 1 to 4 A.M.

The daily average consumption of water in each of the cities and towns supplied from the Metropolitan Works during the years 1904 and 1905, as measured by the Venturi meters, was as follows:—

	Estimated Population. 1905.	DAILY AVERAGE CONSUMPTION.			
		1904.		1905.	
		Gallons.	Gallons per Capita.	Gallons.	Gallons per Capita.
Boston, . . . . .	596,170	87,680,300	149	89,743,900	151
Somerville, . . . . .	69,510	6,228,300	92	6,160,900	89
Malden, . . . . .	38,180	1,868,000	50	2,019,600	53
Chelsea, . . . . .	37,390	4,260,500	116	4,091,200	110
Everett, . . . . .	29,270	2,624,400	93	2,592,400	89
Quincy, . . . . .	28,100	2,823,200	103	3,050,100	109
Medford, . . . . .	19,720	1,802,900	93	1,921,800	97
Melrose, . . . . .	14,350	1,525,100	109	1,601,100	112
Revere, . . . . .	12,930	933,000	75	1,006,800	78
Watertown, . . . . .	11,300	623,600	57	790,700	70
Arlington, . . . . .	9,710	752,400	79	787,700	81
Milton, . . . . .	7,060	316,300	45	320,900	45
Winthrop, . . . . .	7,070	742,300	108	798,300	113
Stoneham, . . . . .	6,320	558,300	89	514,000	81
Belmont, . . . . .	4,370	248,800	58	266,300	61
Lexington, . . . . .	4,060	282,700	72	299,100	74
Nahant, . . . . .	1,840	131,000	69	136,600	74
Swampscott, . . . . .	6,080	521,200	88	534,600	88
District, . . . . .	903,430	113,922,300	128	116,635,900	129



The figures in the column headed "Gallons per Capita" for 1904 are based upon a revised estimate of the population for that year, which has been made since the census of 1905 became available.

The estimated population of the last three towns in the list differs materially from that given by the census. In Lexington, owing to the large number who do not take water from the public supply, 500 has been deducted from the total population of the town. In Nahant and Swampscott, on the other hand, there is a large summer population which takes water but is not included in the census figures. The estimated population of each of these places is therefore increased 920 above the population based upon the census figures.

It will be noticed that there has been about the same proportionate increase in the consumption of water in Boston and in the remaining cities and towns taken as a whole, notwithstanding the fact that the cities and towns other than Boston have reason to be especially interested in diminishing the consumption of water, because, under the provisions of chapter 426 of the Acts of the year 1904, the measurements of the water used by each of these municipalities during the year 1905 will be used in determining the assessment to be paid by each in 1906. It would not be fair, however, to assume that the provisions of this chapter will not effect a saving of water in the outlying cities and towns, as measures are being taken in many of them to introduce meters on the individual services, and when these meters are applied, they will undoubtedly restrict to a large extent the waste of water in places where the meters are used. The consumption of water by each municipality for each month of the year is given in Appendix No. 3, Table No. 22.

The autographic records furnished by the Venturi meters continue to give information regarding unusual drafts of water, and assistance has been rendered to local water departments by notifying them of the increase of flow caused by leaks and by gates left open between high and low service districts.

The consumption of water in the cities and towns supplied from the Metropolitan Water Works, as measured by the meters, is somewhat less than the quantity supplied to the District, as determined by pump measurements, and by the flow in the Weston Aqueduct as measured by a Venturi meter. This difference is in large part accounted for by the quantity of water used at the pumping stations, and by leakage from the pipe lines and reservoirs of the distribution system, this use and leakage not being measured by the meters.



QUALITY OF THE WATER.

Samples of water were collected every two months from seventeen points, and monthly from four points on the works, and sent to the State Board of Health for analysis and examination. Samples of water were also collected each week from many points upon the works, and examined microscopically and for color, odor, taste and turbidity by the biological force of the Metropolitan Water and Sewerage Board.

The quality of the water furnished has been substantially the same as during the past three years, except that the microscopic organisms have been considerably more abundant, especially in the autumn, causing at times an increase in the amount of taste and odor of the water, but the taste and odor have not been such as to cause complaint from the water takers.

The following table gives a comparison of the average results of the examinations of water from a tap in Boston for the years 1900 to 1905, inclusive : —

	1900.	1901.	1902.	1903.	1904.	1905.
<i>State Board of Health Examinations.</i>						
Color (Nessler standard), . . . . .	0.24	0.24	0.26	0.25	0.23	0.23
Total residue, . . . . .	3.80	4.43	3.93	3.98	3.93	3.86
Loss on ignition, . . . . .	1.20	1.64	1.56	1.50	1.59	1.59
Free ammonia, . . . . .	0.0012	0.0013	0.0016	0.0013	0.0023	0.0020
Albuminoid ammonia, {	total, . . . . .	0.0157	0.0158	0.0139	0.0125	0.0139
	dissolved, . . . . .	0.0138	0.0143	0.0119	0.0110	0.0121
	suspended, . . . . .	0.0019	0.0015	0.0020	0.0015	0.0018
Chlorine, . . . . .	0.25	0.30	0.29	0.30	0.34	0.35
Nitrogen as nitrates, . . . . .	0.0076	0.0173	0.0092	0.0142	0.0110	0.0083
Nitrogen as nitrites, . . . . .	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Oxygen consumed, . . . . .	0.38	0.42	0.40	0.39	0.37	0.35
Hardness, . . . . .	1.3	1.7	1.3	1.5	1.5	1.4
<i>Metropolitan Water and Sewerage Board Examinations.</i>						
Color (platinum standard), . . . . .	34	34	33	35	32	28
Turbidity, . . . . .	—	2.0	2.3	2.2	2.4	1.9
Total organisms, . . . . .	468	243	367	286	303	528
Amorphous matter, . . . . .	97	38	34	36	36	37
Bacteria, . . . . .	181	162	164	126	176	231

NOTE. — Chemical analyses are in parts per 100,000, organisms and amorphous matter in standard units per cubic centimeter, and bacteria in number per cubic centimeter. The standard unit has an area of 400 square microns, and by its use the number of diatomaceæ are decreased, and the number of chlorophyceæ and cyanophyceæ are very much increased, as compared with the number of organisms.

More than 8 per cent. of the water supplied to the Metropolitan District passes through Spot Pond, in which the color is, by the bleaching action due to long storage, reduced to about three-fourths of the color of the water supplied to the remainder of the District.

## BIOLOGICAL LABORATORY.

On July 1, Burton G. Philbrick, biologist in charge of the laboratory, resigned, his resignation taking effect on July 6. The vacancy was filled by the appointment on July 13 of Arthur W. Walker.

During the year 2,595 microscopical and 604 bacterial examinations have been made at the laboratory of the Board at 1 Ashburton Place, Boston. Of the microscopical examinations, 1,977 were of the regular samples collected weekly from thirty-seven points and fortnightly from five points on the works, while the remaining 618 were special examinations.

In the Wachusett Reservoir there has been an increase, as compared with the previous year, in the number of organisms, but they were not such as to cause disagreeable odors. The average color has been much lower than that of the previous year.

In the Sudbury Reservoir and Framingham Reservoir No. 3 the microscopic organisms, while quite abundant, gave no trouble.

In Lake Cochituate the organisms were unusually abundant, and at different times during the year large growths of *Synura*, *Uroglena* and *Chlamydomonas* caused considerable trouble; that of *Synura* in January, and *Uroglena* from May to July, were so abundant as to render the water for the time being unsuitable for use, and the flow through the aqueduct was consequently stopped.

The bacteriological work for the year consisted of routine weekly examinations, monthly examinations of the main feeders of the Sudbury Reservoir, of Framingham Reservoir No. 3 and of Lake Cochituate, and monthly tests of the efficiency of the Pegan and Marlborough brook filters. A total of 604 samples were examined.

## SANITARY INSPECTION.

The sanitary inspection of the Wachusett, Sudbury and Cochituate watersheds has been continued during the year, under the direction of William W. Locke, C.E., Sanitary Inspector.

There were 13 reported cases of typhoid fever upon the Wachusett watershed; 12 in Holden and 1 in Princeton. In Holden 8 of the cases occurred at nearly the same time in August in three families, and at each house there was evidence that the well, which was under the house, was polluted from a defective sink drain. One of these drains, which emptied directly into a stream within the watershed,

was at once diverted temporarily into barrels which were regularly emptied, until a satisfactory permanent method of disposal could be provided. On the Sudbury and Cochituate watersheds the total number of typhoid fever cases reported was 27; 12 in Marlborough, 7 in Framingham, 3 in Southborough, 2 in Westborough, 1 in Hopkinton and 2 in Wayland.

The contract work at the Wachusett Reservoir is now nearly finished, which has caused the laborers and those connected with them to go to other places, and has permitted the removal of many buildings in and about the reservoir. The buildings removed in West Boylston in 1905 included 36 dwellings, 6 barns, 1 store and 1 police station, a total of 44, which added to the 271 buildings removed in former years, makes a total of 315 buildings removed to date in this town.

It is of interest to note that very little sickness developed among the laborers or their families during the eight years of contract work upon the site of the reservoir, and that there were only 12 cases of typhoid fever during that period.

During the year the town of Holden has introduced a public water supply which covers all of the principal villages in the town, but as yet not many house connections have been made. When this system is in full working order, it will be much more difficult to maintain the purity of the water in the streams in and near the villages, and some action will probably be necessary in the near future to maintain the purity of this portion of the water supply.

On the Sudbury watershed many men have been employed by the street and steam railways in double-tracking portions of their systems, and short sections of State road have been built, all of this requiring special inspection to prevent the pollution of the waters by the workmen.

At the Fay School, in Southborough, additions were made to the sewage-disposal system which should improve the conditions materially.

A new sanitary census of the Wachusett, Sudbury and Cochituate watersheds was begun in 1904, similar to that taken in 1902 on the Wachusett watershed, and was completed during the year 1905. The census has been tabulated both by municipalities and by districts, and the results are presented in the following tables:—



Wachusett Watershed. — Sanitary Census by Municipalities, 1905.

CITY OR TOWN.	PREMISES.					Area (Square Miles, including Water Surface).	POPULATION.		Permanent Population per Square Mile.	Horses.	Cattle.	Sheep.	Swine.	Poultry.	Dogs.
	Number on which Dwellings occupied throughout the Year.	Summer Cottages.	Number on which there are Stores or Other Buildings, but no Dwellings.	Total Number.	Vacant.		Permanent.	Summer.							
Boylston, . . . . .	72	2	6	80	8	11.12	283	13	25.4	84	331	-	72	2,034	45
Clinton, . . . . .	24	-	-	24	7	1.47	95	-	64.6	2	-	-	-	314	4
Holden, . . . . .	411	2	53	466	20	29.84	2,354	374	78.9	334	823	1	213	15,584	212
Hubbardston, . . . . .	-	-	-	-	-	.06	-	-	-	-	-	-	-	-	-
Leominster, . . . . .	7	-	1	8	2	2.25	19	-	8.4	8	21	-	5	107	3
Paxton, . . . . .	14	7	2	23	3	2.86	61	26	21.3	30	147	-	25	368	13
Princeton, . . . . .	194	46	24	264	22	28.70	732	478	25.5	315	1,028	121	188	4,909	131
Rutland, . . . . .	57	2	4	63	9	8.29	333	16	40.2	85	400	-	193	1,516	34
Sterling, . . . . .	207	213	30	450	17	19.70	732	897	37.2	237	898	28	113	5,705	84
West Boylston, . . . . .	246	1	31	278	14	12.52	1,158	96	92.5	280	606	7	175	6,044	112
Westminster, . . . . .	-	-	-	-	-	.72	-	-	-	-	-	-	-	-	-
Worcester, . . . . .	2	-	-	2	-	.15	5	-	33.3	3	11	-	2	80	1
Totals, . . . . .	1,234	273	151	1,658	102	117.68	5,772	1,900	49.0	1,378	4,265	157	986	36,661	639

Wachusett Watershed. — Sanitary Census by Districts, 1905.

District.	Premises.					Area (Square Miles, including Water Surfaces).	Population.		Permanent Population per Square Mile.	Horses.	Cattle.	Sheep.	Swine.	Poultry.	Dogs.
	Number on which there are Dwellings occupied throughout the Year.	Summer Cottages.	Number on which there are Stores or Other Buildings, but no Dwellings.	Total Number.	Vacant.		Permanent.	Summer.							
French Brook, . . . . .	73	2	5	80	14	7.00	290	13	41.4	56	244	-	36	1,494	36
Muddy Brook, . . . . .	31	-	1	32	-	3.58	125	-	34.9	58	159	-	50	1,686	22
Gates Brook, . . . . .	114	-	16	130	6	3.96	470	-	118.7	122	273	-	116	2,861	49
Malden Brook, . . . . .	15	1	1	17	2	2.55	60	11	23.5	27	77	-	9	660	8
Chaffin Brook, . . . . .	141	-	9	150	12	10.22	694	-	67.9	98	309	-	74	5,460	66
Asnebumskit Brook, . . . . .	225	9	37	271	11	12.91	1,376	300	106.6	198	533	1	255	4,796	110
Muschopauge, . . . . .	82	4	9	95	6	11.67	468	126	40.1	106	416	-	78	6,266	62
South Wachusett Brook, . . . . .	62	10	10	82	14	10.82	218	99	20.1	90	449	101	62	1,781	28
Trout Brook, . . . . .	42	-	5	47	4	8.59	235	-	27.4	54	111	-	25	1,098	27
East Waushacum Brook, . . . . .	154	36	19	209	9	21.26	593	381	27.9	248	608	21	138	3,617	111
Stillwater River, . . . . .	132	1	15	148	8	11.83	665	114	56.2	171	652	20	80	4,471	70
Waushacum, . . . . .	137	210	23	370	10	7.35	497	856	67.6	129	377	7	58	2,495	37
French Hill, . . . . .	26	-	1	27	6	5.94	81	-	13.6	21	57	7	5	576	13
Totals, . . . . .	1,234	273	151	1,658	102	117.68	5,772	1,900	49.0	1,378	4,265	157	986	36,661	639

*Sudbury and Cochituate Watersheds. — Sanitary Census by Municipalities, 1905.*

CITY OR TOWN.	PREMISES.					POPULATION.		Area (Square Miles, including Water Sur- faces).	Population per Square Mile in Dwellings not connected with Sewer. <sup>1</sup>	Horses.	Cattle.	Sheep.	Swine.	Poultry.	Dogs.
	Number on which there are Dwell- ings.	Number on which there are Stores or Other Build- ings, but no Dwellings.	Total Number.	Vacant.	Connected with Sewer.	Total.	In Dwellings not connected with Sewer.								
<i>Sudbury Watershed.</i>															
Framingham, . . . . .	278	35	313	18	205	1,485	438	5.89	74.4	171	381	23	42	3,317	79
Southborough, . . . . .	422	28	450	45	-	1,873	1,873	15.99	117.1	345	1,170	253	158	10,982	30
Marlborough, . . . . .	1,848	124	1,972	66	1,398	10,730	2,518	8.98	280.4	579	450	3	121	11,792	581
Ashland, . . . . .	349	24	373	17	-	1,466	1,466	9.31	157.5	149	205	1	61	5,395	49
Hopkinton, . . . . .	621	36	657	100	-	2,129	2,129	20.87	103.0	243	608	23	113	8,744	148
Westborough, . . . . .	777	63	840	57	295	3,440	2,143	12.36	173.4	304	882	5	167	9,090	195
Northborough, . . . . .	2	-	2	-	-	8	8	1.15	7.0	3	42	-	3	40	1
Upton, . . . . .	-	-	-	-	-	-	-	.74	-	-	-	-	-	-	-
Holliston, . . . . .	-	-	-	-	-	-	-	.11	-	-	-	-	-	-	-
Totals, . . . . .	4,297	310	4,607	303	1,898	21,131	10,575	75.20	140.6	1,794	3,738	308	665	48,460	1,063
<i>Cochituate Watershed.</i>															
Wayland, <sup>2</sup> . . . . .	254	12	266 <sup>3</sup>	8	-	1,276	1,276	3.60	354.4	86	101	-	28	5,603	89
Natick, . . . . .	1,449	103	1,552 <sup>3</sup>	44	718	7,196	3,591	7.85	457.5	435	178	13	234	14,059	402
Sherborn, . . . . .	75	2	77	3	3	617	349	3.61	96.7	72	298	17	203	4,028	44
Framingham, . . . . .	876	76	952	18	706	6,315	1,201	2.40	500.4	306	75	1	124	7,482	261
Ashland, . . . . .	26	-	26	1	-	104	104	2.38	43.7	38	206	-	50	1,154	16
Totals, . . . . .	2,680	193	2,873	74	1,427	15,508	6,521	19.84	328.7	937	858	31	639	32,326	812
Totals for both watersheds, . . . . .															
1,875															

<sup>1</sup> The waters of the streams flowing from the thickly settled parts of Marlborough and Natick are filtered before they enter the reservoirs.  
<sup>2</sup> Including Dudley Pond.      <sup>3</sup> Not including 71 summer cottages and camps on the shores of Lake Cochituate, with a population of 214 on August 1, 1905.



Sudbury and Cochrane Watersheds. — Sanitary Census by Districts, 1905.

District.	PREMISES.					POPULATION.		Area (Square Miles, including Water Sur- faces).	Population per Square Mile in Dwellings not connected with Sewer.	Horses.	Cattle.	Sheep.	Swine.	Poultry.	Dogs.	
	Number on which there are Dwell- ings.	Number on which there are Stores or Other Build- ings, but no Dwellings.	Total Number.	Vacant.	Connected with Sewer.	Total.	In Dwellings not connected with Sewer.									
Sudbury Watershed.																
Farm Pond,	205	32	237	11	205	1,146	99	0.54	183.3	89	2	3	2	356	38	
Framingham Reservoir No. 3,	69	3	72	3	-	286	286	5.35	53.5	83	291	20	38	3,161	23	
Stony Brook,	276	13	289	18	-	1,417	1,417	13.29	106.6	296	1,095	256	140	7,749	41	
Angle Brook,	1,842	124	1,966	65	1,398	10,703	2,491	9.16	271.9	568	436	-	127	11,601	551	
Framingham Reservoirs Nos. 1 and 2, and Cold Spring Brook,	265	9	274	30	-	1,069	1,069	11.72	91.2	157	564	12	91	5,218	67	
Eastern Sudbury,	222	20	242	10	-	901	901	3.11	289.7	66	45	-	22	1,588	30	
Indian Brook,	394	26	420	66	-	1,371	1,371	7.17	191.2	120	195	-	44	4,997	83	
Western Sudbury,	169	15	184	34	-	546	546	7.85	69.6	81	382	-	40	2,584	12	
Whitehall Reservoir,	107	6	113	13	-	368	368	7.61	48.4	78	201	12	33	2,826	34	
Cedar Swamp,	748	62	810	53	295	3,324	2,027	9.40	215.6	256	527	5	128	8,380	184	
Totals,	4,297	310	4,607	303	1,898	21,131	10,575	75.20	140.6	1,794	3,738	308	665	48,460	1,063	
Cochituate Watershed.																
Snake Brook, <sup>1</sup>	304	16	320 <sup>2</sup>	8	-	1,517	1,517	4.73	320.7	111	139	-	186	6,800	99	
Pegan Brook,	836	71	907 <sup>2</sup>	29	505	4,026	1,646	2.24	734.8	313	65	1	16	5,909	202	
Course Brook,	85	3	88	7	1	579	829	3.61	91.1	76	294	16	175	4,907	53	
Beaver Dam Brook,	983	77	1,060	22	708	6,839	1,707	8.15	209.4	382	326	2	242	10,357	311	
Dug Pond,	472	26	498	8	213	2,547	1,322	1.11	1,191.0	55	34	12	20	4,353	147	
Totals,	2,680	193	2,873	74	1,427	15,508	6,521	19.84	328.7	937	858	31	639	32,326	812	
Totals for both watersheds,	6,977	503	7,480	377	3,325	36,639	17,096	95.04	179.9	2,731	4,596	339	1,304	80,786	1,875	

<sup>1</sup> Includes Dudley Pond.

<sup>2</sup> Not including 71 summer cottages and camps on the shores of Lake Cochituate, with a population of 214 on August 1, 1905.

A summary of the work of sanitary inspection for 1905 is given in the following four tables. The first table shows for the Wachusett watershed the number of premises inspected, the classification of cases inspected, and the condition of the premises at the end of the year; the second table gives the corresponding information for the Sudbury and Cochituate watersheds; the third table shows the improvements effected on the Wachusett watershed; and the fourth table the improvements effected on the Sudbury and Cochituate watersheds.

The headings of these tables explain themselves, except in a few instances: under the heading "Premises Vacant" are included all cases which at present furnish no objectionable drainage, but which might furnish such drainage if the premises were occupied; under the heading "Unsatisfactory" are included all cases where there may be, under the most unfavorable conditions, wash from privies or direct sink drainage, all suspected cases, and all cases of manufacturing wastes entering feeders, even though there may be some attempt at previous purification.

In the third and fourth tables no cases are entered as remedied unless complete sewer connections have been made, or all probability of future contamination has been removed; and no cases are entered as partly remedied except where positive improvement in the sanitary condition has been effected.

*Summary of Sanitary Inspections on the Wachusett Watershed in 1905.*

DISTRICT.	Number of Premises inspected. <sup>1</sup>	CLASSIFICATION OF CASES INSPECTED.									CONDITION AT END OF YEAR.	
		Cesspools dug before 1905.	Cesspools dug in 1905.	Direct Privy Drainage.	Indirect Privy Drainage.	Direct Sink Drainage.	Indirect Sink Drainage.	Manure Piles.	Manufacturing Wastes.	Premises Vacant.	Satisfactory.	Unsatisfactory.
French Brook, . . . . .	80	31	1	-	-	2	14	32	-	14	70	10
Muddy Brook, . . . . .	32	8	1	-	-	-	9	24	-	-	31	1
Gates Brook, . . . . .	130	71	6	-	1	3	11	59	-	6	122	8
Malden Brook, . . . . .	17	7	-	-	-	-	1	13	-	2	16	1
Chaffin Brook, . . . . .	150	33	22	-	4	4	16	77	1	12	131	19
Asnebumskit Brook, . . . . .	271	121	12	3	8	26	25	96	3	11	226	45
Muschoyauge, . . . . .	95	34	-	-	6	7	13	51	1	6	76	9
South Wachusett Brook, . . . . .	82	21	-	2	1	4	3	36	-	14	74	8
Trout Brook, . . . . .	47	5	-	-	1	-	5	29	1	4	42	5
East Wachusett Brook, . . . . .	209	56	3	2	7	7	22	108	-	9	186	23
Stillwater River, . . . . .	148	42	2	-	6	2	11	86	-	8	132	16
Wauashacum, . . . . .	164 <sup>2</sup>	42	-	4	7	17	19	65	-	10	125	39
French Hill, . . . . .	27	13	1	-	-	1	-	14	-	6	26	1
Totals, . . . . .	1,452	484	48	11	41	73	149	690	6	102	1,257	195

<sup>1</sup> On some premises there were 2 or more cases.

<sup>2</sup> Not including 206 summer cottages located near the Wauashacum Lakes.

Summary of Sanitary Inspections on the Sudbury and Cochituate Watersheds in 1905.

DISTRICT.	Number of Premises inspected. <sup>1</sup>	CLASSIFICATION OF CASES INSPECTED.									CONDITION AT END OF YEAR.	
		Cesspools dug before 1905.	Cesspools dug in 1905.	Direct Privy Drainage.	Indirect Privy Drainage.	Direct Sink Drainage.	Indirect Sink Drainage.	Manure Piles.	Manufacturing Wastes.	Premises Vacant.	Satisfactory.	Unsatisfactory.
<i>Sudbury Watershed.</i>												
Farm Pond, . . . . .	237	23	-	-	-	-	2	22	-	11	235	2
Framingham Reservoir No. 3, . . . . .	72	32	1	-	-	-	34	49	-	3	69	3
Stony Brook, . . . . .	289	197	4	-	3	2	49	113	-	18	270	19
Angle Brook, . . . . .	1,966	347	8	-	4	8	153	251	1	65	1,882	84
<i>Framingham Reservoirs Nos. 1 and 2, and Cold Spring Brook, . . . . .</i>												
Eastern Sudbury, . . . . .	274	92	5	-	2	-	110	113	-	30	262	12
Indian Brook, . . . . .	242	194	7	-	2	-	48	44	2	11	227	15
Western Sudbury, . . . . .	420	159	9	-	2	7	170	83	-	65	386	34
Whitehall Reservoir, . . . . .	184	60	1	-	4	5	78	54	1	31	155	29
Cedar Swamp, . . . . .	113	22	-	-	1	1	75	37	-	13	102	11
	810	348	2	-	1	6	97	128	1	56	791	19
<i>Cochituate Watershed.</i>												
Snake Brook, . . . . .	320	214	5	-	-	2	93	68	-	8	296	24
Pegan Brook, . . . . .	907	279	8	-	4	4	78	110	2	29	876	31
Course Brook, . . . . .	88	49	-	-	-	-	29	41	-	7	86	2
Beaver Dam Brook, . . . . .	1,060	210	6	-	6	4	92	183	2	22	1,007	53
Dug Pond, . . . . .	498	212	-	-	3	7	42	49	-	8	475	23
Totals, . . . . .	7,480	2,438	56	-	32	46	1,150	1,345	9	377	7,119	361

<sup>1</sup> On some premises there are 2 or more cases.

Sanitary Improvements effected on the Wachusett Watershed in 1905.

DISTRICT.	Remedied. <sup>1</sup>	Partly remedied.
French Brook, . . . . .	8	-
Muddy Brook, . . . . .	2	-
Gates Brook, . . . . .	8	2
Malden Brook, . . . . .	-	-
Chaffin Brook, . . . . .	5	10
Asnebumskit Brook, . . . . .	2	-
Muschopauge, . . . . .	6	-
South Wachusett Brook, . . . . .	8	-
Trout Brook, . . . . .	1	-
East Wachusett Brook, . . . . .	1	-
Stillwater River, . . . . .	20	-
Wachusett, . . . . .	2	-
French Hill, . . . . .	11	1
Totals, . . . . .	74	13

<sup>1</sup> Including buildings burned, torn down or removed.



*Sanitary Improvements effected on the Sudbury and Cochituate Watersheds  
in 1905.*

DISTRICT.	Remedied by Sewer Connection.	Otherwise remedied. <sup>1</sup>	Partly remedied.	Cesspools abandoned on Account of Sewer Connections.
<i>Sudbury Watershed.</i>				
Farm Pond, . . . . .	12	-	-	5
Framingham Reservoir No. 3, . . . .	-	-	1	-
Stony Brook, . . . . .	-	1	4	-
Angle Brook, . . . . .	42	1	8	41
Framingham Reservoirs Nos. 1 and 2, and Cold Spring Brook.	-	-	5	-
Eastern Sudbury, . . . . .	-	4	7	-
Indian Brook, . . . . .	-	-	9	-
Western Sudbury, . . . . .	-	-	1	-
Whitehall Reservoir, . . . . .	-	-	-	-
Cedar Swamp, . . . . .	9	-	2	9
<i>Cochituate Watershed.</i>				
Snake Brook, . . . . .	-	1	5	-
Pegan Brook, . . . . .	44	-	8	37
Course Brook, . . . . .	-	-	-	-
Beaver Dam Brook, . . . . .	34	2	11	33
Dug Pond, . . . . .	20	1	-	19
Totals, . . . . .	161	10	61	144

<sup>1</sup> Including buildings burned, torn down or removed.

Considerable work has been done upon the Wachusett watershed in the building of new cesspools and cemented vaults, as well as by the removal of buildings, already noted. A total of 74 cases were remedied and 48 new cesspools were dug.

The making of sewer connections in the various towns has progressed somewhat faster than in the past.

In Natick fixtures were installed and sewer connections made with 64 houses, against 51 the preceding year, and there are now 718 houses connected with the sewer.

In South Framingham 46 houses have been connected with the sewer, against 45 the preceding year, making a total of 911 houses connected with the sewer.

In Marlborough there have been 45 connections, against 35 the preceding year. There are now 1,398 houses connected with the sewer.

In Westborough 9 connections were made this year, against 13 the preceding year, and to date only 295 premises have sewer connections.

#### DRAINAGE OF SWAMPS.

On the ditches tributary to the open channel it has been necessary during the year to replace 15 wooden bridges across the ditches and to repair 2 others, at a total cost of \$220. The usual work at these ditches has been done by the regular attendants.

The drainage ditches in the vicinity of the Sudbury Reservoir were cleaned twice during the year, and in August the brush was cut for a width of about 10 feet on each side of the ditches.

#### DISTRIBUTING RESERVOIRS.

The distributing reservoirs maintained by the Board are the Weston and Chestnut Hill reservoirs, the Waban Hill and Forbes Hill reservoirs and the Forbes Hill standpipe of the southern high-service system; Spot Pond and the Mystic Reservoir, near Tufts College, of the northern low-service system; the Fells and Bear Hill reservoirs of the northern high-service system; and the Arlington standpipe of the northern extra high-service system.

##### *Weston Reservoir.*

The grounds about the reservoir have been kept in good order. The old Upham house on Ash Street was extensively repaired, and has been occupied since September by one of the employes.

##### *Chestnut Hill Reservoir.*

In addition to the usual care of the gate-houses and grounds, repairs have been made at this reservoir as follows: about 30 square yards of granolithic walk were laid in front of the low-service station, to replace that damaged by the break in the 30-inch pipe line in February, 1904. About 2,650 linear feet of gravel walks around the reservoir were rebuilt. The lawn in front of the pumping stations and the great circle between the basins were dug up and reseeded in the fall. A considerable amount of work was done repairing windows and setting glass in effluent gate-houses Nos. 1 and 2 and the terminal chamber. The ironwork was cleaned and painted in the influent and intermediate gate-houses, in the small gate-house over the Cochituate

Aqueduct on Reservoir Lane, and in the screen-chamber in the high-service station. Gypsy moths in large numbers made their first appearance here, and much time was spent in destroying their nests. More brown-tail moths were found than in any previous year.

*Waban Hill Reservoir.*

The reservoir and gate-house are in good condition. The banks of the reservoir have been loamed, seeded and rolled, and the iron-work in the gate-house has been cleaned and painted.

*Forbes Hill Reservoir and Standpipe.*

The woodwork and the ironwork of the tower and reservoir gate-chamber, and the iron railing around the reservoir, have been kept painted by the attendant.

*Spot Pond.*

While repairs were being made to the Weston Aqueduct, water was drawn from the pond for the supply of the District from January 25 to February 20, and the water fell to about 4 feet below high water; on April 1 it had risen to within 6 inches of high water. During repairs to the Sudbury Aqueduct, water was drawn from the pond from April 11 to April 23, and the water fell to about 2 feet below high water. From the middle of May until the end of the year the pond has remained at or near high water except from September 2 to September 9, when heavy rains caused it to rise about 6 inches above high water. The reservoir and grounds about the pumping station are in good condition. The Bottume house has been repaired, and is now occupied by the foreman. In the meadow off South Street, Stoneham, 130 feet of 5-inch tile drain were laid, to replace 3-inch which had proved too small. For the double purpose of improving the character of the wooded areas and of reducing the number of trees to be protected from gypsy and brown-tail moths, a large number of trees on the thickly wooded areas have been cut down. About 563 cords of wood and 253 logs were cut and piled. Between February 24 and July 21 creosote was applied to the egg clusters of the gypsy moth, and bands of burlap and of tanglefoot were placed around the trees, and the foliage was sprayed with disparene. A large number of caterpillars, however, appeared in the spring from off the ground, due, probably, to broken egg



clusters accidentally scraped from the trees which were cut down during the winter. Tanglefoot was applied to each tree as soon as the new caterpillars were discovered, but not soon enough to prevent thousands from getting into the trees. At several points windrows of hay sprinkled with gas oil were used to prevent the caterpillars from entering the property of the Board from surrounding land which had not been protected. As a result of these measures, the foliage on the trees on the land of the Board was injured but very little, and showed a marked contrast to that on adjoining property.

### *Mystic Reservoir.*

The reservoir had not been cleaned for thirteen years, and on September 16 it was shut off and drained for that purpose. With the exception of two cracks, the brick lining was found to be in good condition. An accumulation of about 3 inches of silt was found on the bottom of the two basins, 260 cubic yards of which was hoisted out and spread on the banks, and the remainder washed out through the drain. The cement covering on the 30-inch pipe through the easterly basin was found to be badly cracked, and was removed, the pipe cleaned, painted with vulcanite and again covered with a mixture of 1 part of Portland cement to 3 parts of sand. The work of refilling began on October 6, the reservoir having been shut off for nineteen days. In addition to the silt from the reservoir, 19 cords of manure was spread upon the banks. The tin roof of the gate-house has been extensively repaired and the exterior painted, the stonework of the reservoir partially repointed, and the trees cleared of moths. A local police officer was on duty on Sunday afternoons and evenings during May and June, to assist the attendant in preserving order.

### *Fells and Bear Hill Reservoirs.*

In order to keep out the rain, metal tops were placed on the chimneys on the gate-houses at both reservoirs. The reservoirs, with their gate-houses and grounds, are in good order.

### *Arlington Standpipe.*

The standpipe has been in service throughout the entire year.

*Mystic Lake.*

The water in the lake was kept from 2½ to 3 feet below high water from the first of January until the last of April. From this time until the end of the year it was kept from 1½ to 2 feet below high water, and on January 1, 1906, stood at elevation 15.50 above Boston City Base, or 1½ feet below high-water mark. The work here has consisted principally of destroying moths, cutting and burning underbrush and repairing fishway. The Medford Boat Club has had shingled the roofs of the buildings which they use for the storage of boats.

## PIPE LINES.

Sixteen leaks were repaired on the pipes, at a cost of \$474.95. The only break in the pipe lines occurred on October 28, near the low-service pumping station at Chestnut Hill, in the 36-inch force main to Fisher Hill Reservoir. The repairing of this break, which was caused by uneven settlement, cost \$180.78, exclusive of the work remaining to be done on the lawn and walk.

The supply pipe line was out of service from March 5 to March 14, while masons were working in the Weston Aqueduct. The river crossings were tested in the spring and fall as usual, and in October it was necessary to secure the services of a diver to repair four joints in the Mystic River and one joint in the Charles River which were found to be leaking badly.

In order to allow shutting off the supply to Orient Heights, when necessary, without interfering with the flow to Winthrop, a 12-inch valve was placed in the line at Atlantic and Crescent avenues, Revere. The work of making connections between the pump in the low-service station at Chestnut Hill and the 36-inch force main to Fisher Hill Reservoir was begun early in November, and is still in progress. Considerable work was done on valve chambers to make them conform to the new grades established for streets in various parts of the Metropolitan District.

All the pipe bridges with the exception of the Western Avenue bridge over the Saugus River have been cleaned and painted, and the stonework in the abutments of the Mystic River pipe bridge was repointed.

Twenty-one recording pressure gages are now in use, connected with the distribution system at different points. The average maxi-

mum and minimum elevations of the water, due to the pressure at seventeen points in different parts of the District, are given in Appendix No. 3, Table No. 38.

#### METERED CONNECTIONS.

The number of metered connections with the main pipes of cities and towns in service in the Metropolitan Water District, on January 1, 1906, was 56, 2 having been added during the year. Of these connections, 54 are supplied through Venturi meters and 2 through the ordinary form of water meter. Two new meters have been added during the year, one on the main supplying Stoneham, and another on the main supplying Breed's Island high-service. The first of these was a Venturi meter, having a 12-inch tube with a 4-inch throat; and the other was a 3-inch Hersey disc meter, set in a by-pass of small diameter, a large emergency flow being provided for by a weighted check valve placed in the 12-inch pipe from which the meter by-pass was taken. The 20-inch Venturi meter at Webster Avenue and Newton Street, Somerville, was replaced with a 24-inch meter.

The outside operation and maintenance have continued to be cared for by two men, who, besides the work of reading and winding the registers, have cleaned, oiled, painted and repaired the registers and chambers.

As no further trouble from freezing of the water in the registers was experienced with the seven meter tanks treated last year with an insulated coating of pitch and cork, six more tanks, with which similar trouble had been experienced, have been treated in like manner. This work was done by the maintenance force, at a cost of about \$48.50 per chamber, or \$21.50 less per chamber than last year.

#### ELECTROLYSIS.

Investigations of the electrical conditions surrounding the pipes in the Distribution System have been continued during the year. A complete voltmeter survey of the entire district was made about April 1, and another about November 1. A large number of miscellaneous investigations have also been conducted in connection with experimental work pertaining to electrolysis of water pipes. The distribution and magnitude of the differences of electrical potential, or electrical pressures, and of the electric currents flowing on



the pipes, which result from these pressures and produce the disintegration of the pipes, have been obtained from the voltmeter surveys.

With the exception of the change produced artificially by setting the insulation joints on the two 48-inch low-service pipe lines connecting the Chestnut Hill pumping station and Spot Pond, the electrical conditions have remained about the same as during 1904.

There has probably been a slight increase in the rate of disintegration of the pipes in the vicinity of the power stations in Chelsea and Lynn, this year. A thorough examination of the pipes in these districts was made in 1903, and about 600 feet of 12-inch pipe line in the vicinity of the Lynn power station, which had been the most seriously damaged by electrolysis, was relaid with new pipe last year. No excavations have been made to determine the conditions of these pipes this year, as it is difficult to determine definitely the amount of injury done in a short interval of time.

The electrical conditions surrounding our 20-inch pipe in Main Street, Stoneham, and 12-inch pipe in West Street, Hyde Park, tend to cause the disintegration of the pipes. An examination of the pipe in West Street, Hyde Park, was made in June, 1904; and it was found that, on account of the pipes being surrounded by dry, gravelly soil, the electrolytic action was quite uniformly distributed over the entire pipe surface, and the pittings were not very deep at any point. As the soil conditions in Main Street, Stoneham, are quite similar to those in Hyde Park, no attempt has been made to determine the extent of the deterioration of the 20-inch pipes at this place this year, as it is probable that it will be several years before the disintegration of the iron will cause them to be unsafe.

At the close of last year the work of setting insulation joints at several points on the pipe lines in the district covered by the Boston Elevated Railway Company was in progress, and four of the joints had been set in the westerly 48-inch pipe line connecting Chestnut Hill pumping station and Spot Pond.

In January of this year insulation joints were set at two points on the easterly 48-inch pipe line connecting Chestnut Hill pumping station and Spot Pond. These joints were set on the electrically positive side of the Charles and Mystic rivers, for the purpose of reversing the polarity of the pipes submerged under these rivers, so that the pipes would be negative instead of positive to the sur-

rounding earth and water, with the result that the electricity would flow on to them from the earth without causing damage, instead of flowing from them into the earth, and causing a disintegration of the iron.

The joints are located in Middlesex Avenue, Medford, at a point about 2,100 feet north of the shore of the Mystic River, and in land of the Commonwealth which was a portion of the Francis estate in Boston, at a point about 200 feet south of the shore of the Charles River.

The setting of these joints completed all the work which had been planned, for experimental purposes, under an agreement with the Boston Elevated Railway Company. The total cost of setting these joints at the six points on the two 48-inch pipe lines was \$3,700.80.

In the last annual report certain conclusions were drawn from a necessarily rather incomplete investigation of the effect of the insulation joints which had been set. Complete investigations made during this year have, however, confirmed the conclusions reached last year.

Investigations made this year show that the reversal of the electrical condition of the pipe lines under the Charles and Mystic rivers has been accomplished as anticipated, as these sections of the pipe lines are now receiving about 35 amperes of electricity, instead of losing about 60 amperes, as formerly.

On the portions of the pipe lines directly affected by the insulation joints there has been a substantial reduction in the amount of electricity leaving the pipes in wet ground and in the total amount of electricity leaving the pipe lines, but the currents remaining on the pipes are still of such magnitude as to cause serious injury at many points.

By creating new positive districts the joints have caused a distribution of the damage over many portions of the pipe systems where it will be more difficult to locate it, and in a measure have destroyed the benefit which resulted from connecting the positive bus-bar to the railway feed wires, which was done several years ago, so as to concentrate the injury to the pipes in the district near the power station, where it could be most easily located.

No extensive examination has been made of the pipe lines in any of these new positive districts on the positive side of the insulation joints where damage is expected from electrolysis, due to the differ-



ence of potential maintained across the joints, because it would be difficult to detect the injury done in a single year, except where the soil conditions are favorable to rapid action; but an examination of the top of the flanges at insulation joint No. 6 in Middlesex Avenue, where exposed in the chamber, revealed several distinct pits about  $\frac{1}{4}$  of an inch deep on the positive flange; the negative flange was unaffected. This joint is covered with water during a considerable portion of the year.

Since the insulation joints have been set, it has been possible to obtain a more accurate measure of the total fall of potential on the Boston Elevated tracks and return system than in the past. This "return drop," as it is often called, was found to average as high as 20 volts during the "average load" periods and 40 volts during "peak load" periods, which is much in excess of the 7 volts allowed by the government regulations in England, and an even smaller limit allowed by the government regulations in France and Germany.

Our investigations have shown that the amount of injury to pipes from electrolysis in any given district is directly proportional to the "return drop;" and that a very large reduction in the amount of electrolytic damage could be made by the railway company, by reducing the "return drop" so as to conform to the foreign practice.

The "return drop" on the Boston & Northern and Old Colony street railways has not been accurately obtained, but is somewhat larger than the "return drop" on the Boston Elevated Railway.

Several cases of damage to the local water pipes from electrolysis have been discovered in Boston, Chelsea, Cambridge and Hyde Park during the year, which were due to the bonding of the underground telephone cable sheaths to the tracks, to protect them from electrolysis. These facts have shown us that it is very important to obtain the differences of potential between our pipes and the telephone cables. The location of the fifty or more bonds between the telephone cable and the railway returns has already been obtained, and arrangements have been made to obtain the differences of potential between the cables and our pipes early next year.

Tests have been made during the year of several insulation coatings applied to short pieces of pipe, and some of them were of very high resistance; but, on account of the mechanical difficulties to be



overcome in applying a perfect coating and preserving it in perfect condition in practical use, there appears to be very little chance of preventing electrolysis by their use.

#### CLINTON SEWERAGE.

The Clinton sewage disposal works were in daily operation during the whole year. The amount of sewage pumped and filtered was about 97,000 gallons per day less than during the preceding year. This decrease was due largely to the comparatively small amount of water which has been allowed to run in the river, and the consequent decrease in the amount of water entering a leaky section of the town sewers located close to the river, between the Lancaster Mills and Germantown. A small part of the decrease is due to the extension of the metering of house services in Clinton, by which the waste of water has been checked.

Following are statistics relating to the operation of the pumping station : —

Daily average quantity of sewage pumped (gallons), . . . .	643,000
Daily average quantity of coal consumed (pounds), . . . .	1,175
Gallons pumped per pound of coal, . . . . .	547
Number of days pumping, . . . . .	365
Cost of pumping : —	
Labor, . . . . .	\$1,217 11
Fuel, . . . . .	969 63
Repairs and supplies, . . . . .	256 41
<hr/>	
Total for station, . . . . .	\$2,443 15
Cost per million gallons pumped, . . . . .	\$10 41
Cost per million gallons raised 1 foot high, . . . . .	21

#### *Filter-beds.*

The 8 settling basins which were put in operation during November of the previous year have been in continuous operation during the present year. During January, February, March and December the sewage was turned through a basin which was used continuously for two weeks, when the sewage was drawn off and another basin used. After March, until July first, the sewage was allowed to run through a basin for one week, and was drawn off after standing in the basin two days. After July first, until December, the sewage

was allowed to run through a basin for three days, and was almost immediately drawn off and another basin put in use.

Considerable sludge has accumulated in the basins, which has been removed by the farmers after being allowed to dry out for about a week.

While passing through and standing in the basins rather more than 5 per cent. of the water is lost by seepage into the ground.

The use of the basins has not materially improved the character of the effluent from the filter-beds.

During the warmer part of the year the sewage was applied in about the same quantity per bed to the 19 beds from which all soil had been removed and to the 6 beds from which soil had not been removed; but the latter beds were not used during the colder part of the year. From May 4 to November 30 the sewage was applied to a bed having an area of 1 acre, for about one and one-half hours, the amount per application being about 143,000 gallons, and each bed was used about once in six days, which gives an average of about 23,000 gallons of sewage per acre per day.

During the colder portion of the year, when the temperature was below 15° above zero, all the sewage of one day's pumping was applied to one of 5 improved beds which had been prepared with furrows 3 feet 6 inches apart, the average amount per application being 523,000 gallons, and each furrowed bed was used about once in thirteen days. When the temperature was higher than 15° above zero, the sewage was applied to improved beds which had not been furrowed, for about two and one-half hours, at the rate of about 336,000 gallons per application, and each bed was used about once in eleven days.

The degree of purification has been about the same as during preceding years. The amount of organic matter removed has been somewhat greater than for any year since 1901; but the nitrification has hardly been as good, the nitrates in the effluent being lower than in any previous year since the works have been operated. The purification during the last half of the year has been markedly better than during the first half, as has been usual in other years.

The results of chemical analyses of the sewage and effluent are given in the following table: —

[Parts per 100,000.]

	1900.	1901.	1902.	1903.	1904.	January to June, 1905, inclusive.	July to December, 1905, inclusive.	Whole Year, 1905.
Albuminoid ammonia, sewage.	1.380	1.0025	1.0517	.9233	.7967	.8467	1.4033	1.1250
Albuminoid ammonia, effluent.	.089	.0741	.0891	.0782	.0686	.0801	.0772	.0787
Per cent. removed, . . .	94	91	89	92	91	91	94	93
Oxygen consumed, sewage,	14.84	10.73	8.85	8.65	8.57	11.72	14.50	13.11
Oxygen consumed, effluent,	1.09	.82	1.15	1.12	.99	1.22	1.02	1.126
Per cent. removed, . . .	93	91	84	87	88	90	93	91
Free ammonia, sewage, .	3.9500	3.4533	4.3284	3.8292	3.97	3.9600	5.5467	4.7533
Free ammonia, effluent, .	1.0631	.5792	.6862	1.0185	.99	1.0713	.8360	.9588
Per cent. removed, . . .	73	83	84	73	75	73	85	80
Nitrogen as nitrates, effluent.	.7300	.9298	.9815	.4168	.4046	.1866	.3536	.2665

The cost of maintaining the filter beds, exclusive of the cost of building some board-bottom paved ditches and laying pipe drains to drain contiguous land, and of repairs on houses belonging to the Board, for which \$336.17 has been expended for labor and supplies, has been as follows : —

Labor, . . . . .	\$2,475 73
Repairs and supplies, . . . . .	77 70
Total, . . . . .	\$2,553 43
Cost per million gallons filtered, . . . . .	\$10 88

Appended to this report are tables of contracts giving the amount of work done and other information, a statement of the cement tests, a long series of tables relating to the maintenance of the Metropolitan Water Works, tables showing the length of main pipes and number of service pipes, meters and fire hydrants in the Metropolitan Water District, and a summary of statistics for 1905.

Respectfully submitted,

FREDERIC P. STEARNS,

Chief Engineer.



## REPORT OF ENGINEER OF SEWERAGE WORKS.

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*To the Metropolitan Water and Sewerage Board.*

GENTLEMEN : — The following is a report of the operations of the Engineering Department of the Metropolitan Sewerage Works for the year ending December 31, 1905.

### ORGANIZATION.

The engineering organization during the year has been as follows : —

#### *Division Engineers : —*

FREDERICK D. SMITH, . *In charge of maintenance, South Metropolitan System, and construction of High-level Sewer in Quincy and Milton.*

FRANK I. CAPEN, . . *In charge of maintenance and construction, North Metropolitan System.*

FRANK A. EMERY, . . *In charge of office, drafting room and records.*

In addition to the above, there were employed at the end of the year 8 engineering and other assistants.

METROPOLITAN SEWERAGE DISTRICTS.

AREAS AND POPULATIONS.

During the year no changes have been made in the extent of the sewerage districts. The area of the North Metropolitan District remains at 90.50 square miles, and of the South Metropolitan District at 100.87 square miles,—a total, inclusive of water surfaces, of 191.37 square miles. These districts include the whole or parts of 25 cities and towns, as set forth in the following table.

The populations in the table are based on the census of 1905. It will be noted that the recent census returns do not fully justify all the published forecasts of earlier reports.

Table showing Areas and Estimated Populations within the Metropolitan Sewerage District, as of December 31, 1905.

CITY OR TOWN.		Area (Square Miles).	Estimated Population.
North Metropolitan District.	Arlington, . . . . .	5.20	9,820
	Belmont, . . . . .	4.66	4,390
	Boston (portions of), . . . . .	3.45	93,275
	Cambridge, . . . . .	6.11	98,210
	Chelsea, . . . . .	2.24	37,700
	Everett, . . . . .	3.34	29,770
	Lexington, <sup>1</sup> . . . . .	5.11	2,800
	Malden, . . . . .	5.07	38,610
	Medford, . . . . .	8.35	19,900
	Melrose, . . . . .	3.73	14,500
	Revere, . . . . .	5.86	12,950
	Somerville, . . . . .	3.96	70,200
	Stoneham, . . . . .	5.50	6,340
	Wakefield, . . . . .	7.65	10,410
	Winchester, . . . . .	5.95	8,400
South Metropolitan District.	Winthrop, . . . . .	1.61	7,140
	Woburn, . . . . .	12.71	14,430
		90.50	478,845
	Boston (portions of), . . . . .	20.39	144,200
	Brookline, . . . . .	6.81	23,910
	Dedham, <sup>1</sup> . . . . .	9.40	7,400
	Hyde Park, . . . . .	4.57	14,630
	Milton, . . . . .	12.59	7,090
	Newton, . . . . .	16.88	37,240
	Quincy, . . . . .	12.56	28,160
	Waltham, . . . . .	13.63	26,600
	Watertown, . . . . .	4.04	11,420
Totals, . . . . .		191.37	779,495

<sup>1</sup> Part of town.

## METROPOLITAN SEWERS.

## SEWERS PURCHASED AND CONSTRUCTED AND THEIR CONNECTIONS.

Within the Sewerage Districts there are now 96.12 miles of Metropolitan sewers. Of this total, 8.79 miles of sewers, with the Quincy pumping station, have been purchased from cities and towns of the districts, the remaining 87 miles of Metropolitan sewers having been constructed by the Metropolitan boards.

The position, lengths and sizes of these sewers are given in the following tables, together with other data referring to the public and special connections with the system:—

*North Metropolitan System.*

CITY OR TOWN.	Size of Sewers.	Length in Miles.	Public Connections, December 31, 1905.	SPECIAL CONNECTIONS.	
				Character or Location of Connection.	Number in Operation.
Boston:—					
Deer Island, .	6' 3" to 9', . . . .	1.367	4	-	-
East Boston, .	9' to 1', . . . .	5.467	20	-	-
Charlestown, .	6' 7"×7' 5" to 1', . . .	3.292	13	Navy Yard, . . . .	7
Winthrop, . .	9', . . . .	2.864	7	Alms-house, . . . .	1
Chelsea, . . .	8' 4"×9' 2" to 1' 10"×2' 4", .	5.123	7	Club house, . . . .	1
Everett, . . .	8' 2"×8' 10" to 4' 8"×5' 1", .	2.925	6	Fire Dept. Station, . . .	1
Malden, . . .	4' 6"×4' 10" to 1' 3", . . .	3.931 <sup>1</sup>	26	Bakery, . . . .	1
Melrose, . . .	4' 6"×4' 10" to 10", . . .	6.099 <sup>2</sup>	31	Rendering works, . . . .	1
Cambridge, . .	5' 2"×5' 9" to 1' 3", . . .	7.167	29	Metropolitan Water Works blow-off, . . . .	1
Somerville, . .	6' 5"×7' 2" to 1' 10"×2' 3", .	3.471	10	Metropolitan Water Works blow-off, . . . .	1
Medford, . . .	4' 8"×5' 1" to 10", . . .	5.359	20	Metropolitan Water Works blow-off, . . . .	1
Winchester, . .	2' 11"×3' 3" to 1' 3", . . .	6.428	13	Private buildings, . . . .	113
Stoneham, . . .	1' 3" to 10", . . . .	0.010	4	Private buildings, . . . .	106
Woburn, . . .	1' 10"×2' 4" to 1' 3", . . .	0.933	3	Factory, . . . .	1
Arlington, . . .	1' 6" to 10", . . . .	3.520 <sup>3</sup>	33	Railroad station, . . . .	1
Belmont, <sup>4</sup> . . .	-	-	3	Slaughter-house, . . . .	1
Wakefield, <sup>4</sup> . .	-	-	1	City Hospital, . . . .	1
Revere, . . .	4' to 3', . . . .	0.048	2	Tannery, . . . .	1
				Slaughter-houses (3), . . .	1
				Car-house, . . . .	1
				Stable, . . . .	1
				Armory building, . . . .	1
				Private buildings, . . . .	5
				Stable, . . . .	1
				Tannery, . . . .	2
				Private buildings, . . . .	2
				Gelatine factory, . . . .	1
				Stable, . . . .	1
				Railroad station, . . . .	1
				-	-
				Glue factory, . . . .	1
				Private buildings, . . . .	90
				Railroad station, . . . .	1
				Car-house, . . . .	3
				-	-
				-	-
				-	-
		58.004 <sup>5</sup>	232		351

<sup>1</sup> Includes .988 of a mile of sewer purchased from the city of Malden.

<sup>2</sup> Includes .736 of a mile of sewer purchased from the town of Melrose.

<sup>3</sup> Includes 2.631 miles of sewer purchased from the town of Arlington.

<sup>4</sup> The Metropolitan sewer extends but a few feet into the towns of Belmont and Wakefield.

<sup>5</sup> Includes 2.787 miles of Mystic River valley sewer in Medford, Winchester and Woburn, running parallel with the Metropolitan sewer.



South Metropolitan System.

CITY OR TOWN.	Size of Sewers.	Length in Miles.	Public Con- nections, Decem- ber 31, 1905.	SPECIAL CONNECTIONS.	
				Character or Location of Connection.	Number in Opera- tion.
Boston (Back Bay),	6' 6" to 5' 6", . . .	1.500 <sup>1</sup>	8	Private house, . . . . .	1
Boston (Brighton),	5' 6" to 12", . . . .	3.714 <sup>2</sup>	11	Administration building, Boston Park Department, .	1
Boston (Dorches- ter).	3'×4' to 2' 6"×2' 7", .	2.870 <sup>3</sup>	7	Simmons College buildings, .	1
Boston (Roxbury),	6' 6"×7', 4' 0", . . .	1.430	-	Abattoir, . . . . .	3
Boston (West Rox- bury).	9' 3"×10' 2" to 12", .	7.011	9	Chocolate works, . . . .	2
Brookline, . . . .	5' 6", . . . . .	0.127	2	Paper mill, . . . . .	1
Dedham, . . . . .	4'×4' 1" to 3' 9"×3' 10",	2.350	4	Private buildings, . . . .	2
Hull, . . . . .	60" pipe, . . . . .	0.750	-	- . . . .	-
Hyde Park, . . . .	10' 7"×11' 7" to 4'×4' 1",	4.527	14	- . . . .	-
Milton, . . . . .	11'×12' to 8", . . . .	3.600	8	Private buildings, . . . .	2
Newton, . . . . .	4' 2"×4' 9" to 1' 3", .	2.911	6	- . . . .	-
Quincy, . . . . .	11' 3"×12' 6" to 24" pipe,	6.580	3	Private houses, . . . . .	2
Waltham, . . . . .	3' 6"×4', . . . . .	0.001	1	- . . . .	-
Watertown, . . . .	4' 2"×4' 9" to 12", .	0.750 <sup>4</sup>	5	Factories, . . . . .	2
		38.121	78		22

<sup>1</sup> Includes .355 of a mile of sewer purchased from the city of Boston.  
<sup>2</sup> Includes .026 of a mile of sewer purchased from the town of Watertown.  
<sup>3</sup> Includes 1.24 miles of sewer purchased from the city of Boston.  
<sup>4</sup> Includes .025 of a mile of sewer purchased from the town of Watertown.

COST OF CONSTRUCTION.

The cost of the 96 miles of Metropolitan sewers enumerated above, including seven stations, siphons and appertaining structures, may be summarized as follows : —

North Metropolitan System, . . . . .	\$6,088,830 56
South Metropolitan System, . . . . .	7,624,042 66
	<hr/>
	\$13,712,873 22

Information relating to areas, populations, local sewer connections and other data for the whole Metropolitan Sewerage District appear in the following table : —

North Metropolitan District.

Area (Square Miles).	Estimated Total Population.	Miles of Local Sewer connected.	Estimated Population contributing Sewage.	Ratio of Contributing Population to Total Population (Per Cent.).	CONNECTIONS MADE WITH METRO- POLITAN SEWERS.	
					Public.	Special.
90.50	478,845	573.57	376,575	78.6	232	351

South Metropolitan District.

Area (Square Miles).	Estimated Total Population.	Miles of Local Sewer connected.	Estimated Population contributing Sewage.	Ratio of Contributing Population to Total Population (Per Cent.).	CONNECTIONS MADE WITH METRO- POLITAN SEWERS.	
					Public.	Special.
100.87	300,650	439.74	156,360	52.0	78	22

Entire Metropolitan District.

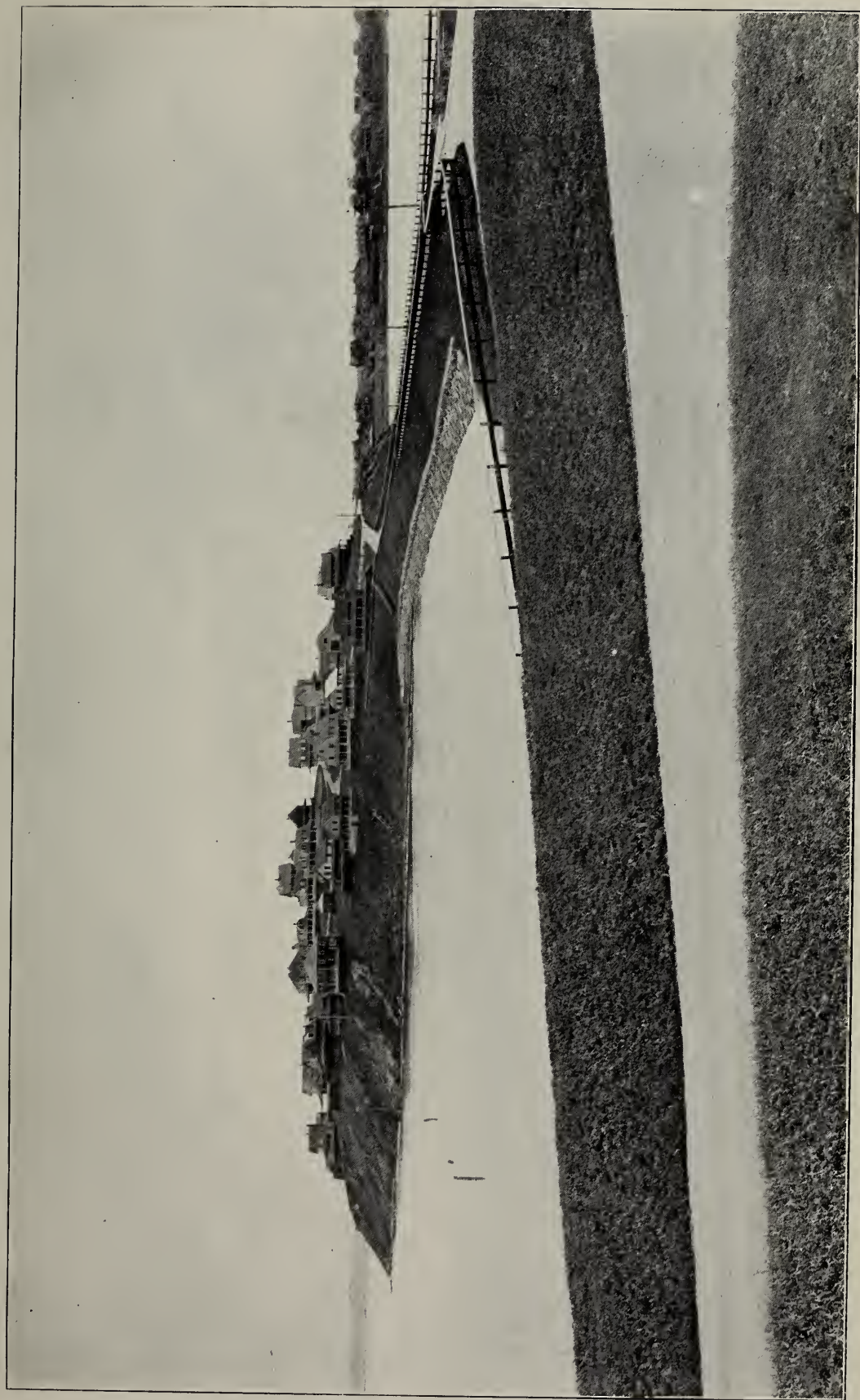
191.37	779,495	1,013.31	532,935	68.4	310	373
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Of the estimated gross population of 779,495 on December 31, 1905, 532,935, representing 68.4 per cent., were on that date contributing sewage to the Metropolitan sewers, through a total length of 1,013.31 miles of local sewers owned by the individual municipalities. These sewers are connected with the Metropolitan System by 310 public and 373 special connections. It appears, also, that there has been during the year an increase of 48.81 miles of local sewers connected with Metropolitan System, and that 12 public and 26 special connections have been added.

PUMPING STATIONS AND PUMPAGE.

The following table shows the average daily volume of sewage lifted at each of the six Metropolitan pumping stations during the year, as compared with corresponding volumes for the previous year : —

PUMPING STATION.	AVERAGE DAILY PUMPAGE.			
	Jan. 1, 1904, to Dec. 31, 1904.	Jan. 1, 1905, to Dec. 31, 1905.	Decrease during the Year.	
	Gallons.	Gallons.	Gallons.	Per Cent.
Deer Island, . . . . .	57,200,000	54,400,000	2,800,000	4.9
East Boston, . . . . .	55,000,000	52,400,000	2,600,000	4.7
Charlestown, . . . . .	31,100,000	29,900,000	1,200,000	3.9
Alewife Brook, . . . . .	3,546,000	3,234,000	312,000	8.8
Quincy, . . . . .	3,651,000	3,180,000	471,000	12.9
Ward Street, . . . . .	-	20,940,000	-	-



HIGH-LEVEL SEWER—EMBANKMENT CONNECTING GREAT HILL IN QUINCY WITH NUT ISLAND.





## CONSTRUCTION.

### SOUTH METROPOLITAN SYSTEM.

During the year all construction carried out by the department has been on the South System, by day labor, under the direction of the maintenance engineers and foremen.

This has included grading, loaming slopes and grounds at Nut Island and vicinity, and at the Ward Street pumping station; the construction of roads about the Nut Island screen house and the Ward Street station; the placing of a 24-inch force main connecting the Quincy pumping station with the High-level Sewer at Greenleaf Street, Quincy; and the reversal of grade of the lower end of the Charles River main sewer by a new concrete invert from Bryant Street to Vancouver Street. This latter work is now in progress.

### GRADING AT NUT ISLAND AND VICINITY.

At the beginning of the year the grounds at Nut Island and the surface and slopes of embankments connecting Nut Island and Great Hill, and over the line of Section 46 from Island Avenue to near Prospect Avenue, were in a rough and unfinished condition, as left under various earlier contracts, described in previous reports.

During the year roads have been built over both of the embankments above noted. The roads were about 20 feet in width, with 3-inch gravel surfaces rolled. From Nut Island to Great Hill the road is protected on both sides of the embankment by wooden fences. Roads of similar construction have been built from the screen house to the wharf and from the wharf to the beach. There have been 2,550 linear feet thus constructed at Nut Island and vicinity, involving 5,500 square yards of road surfaces.

During the earlier construction at Nut Island about 4,000 cubic yards of loam were stored from the excavation. During the season the surfaces of the island have been graded to a rolling condition not unlike that found on the island when purchased. These surfaces have been covered with from 8 inches to 12 inches of loam. The slopes and surfaces of both embankments before referred to have been loamed from the road to the riprap line, at about 10 feet above average high water of the harbor. Practically all of the stored loam has been used in this work. All loamed surfaces have been seeded.

### QUINCY FORCE MAIN.

The Quincy pumping station, which was purchased by the Board in 1901 from the city of Quincy, was at that date connected by a cast-iron pipe with Boston Main Drainage Works at Squantum.

After the opening of the High-level Sewer, in November, 1904, arrangements were made for breaking off this connection with the city of Boston works, and connecting this station with the Metropolitan Sewer in Greenleaf Street, in Quincy, by means of a new 24-inch cast-iron pipe. The route of this new force main is in a general easterly direction from the station through Merrymount Park, across Furnace Brook Parkway of the Metropolitan System, along Park Lane and Valley Street to Greenleaf Street. The total length of the new line is 3,025 feet. The pipe as laid has a thickness of .72 of an inch and a weight of 2,290 pounds for 12-foot lengths.

Through the city park the excavation was largely in loam and peat; for a length of 135 feet the pipe is supported on piles 25 feet long. The pipe leaves the pumping station at about 4 feet below the engine room floor, at about 8 feet above the level of average low tide. An 8-inch pipe branch leads back from this line to the suction sewer, providing for quickly draining the main pipe. The pipe has a uniformly rising grade without summit, entering the main sewer at Greenleaf Street, at 16 feet above the elevation of average low water.

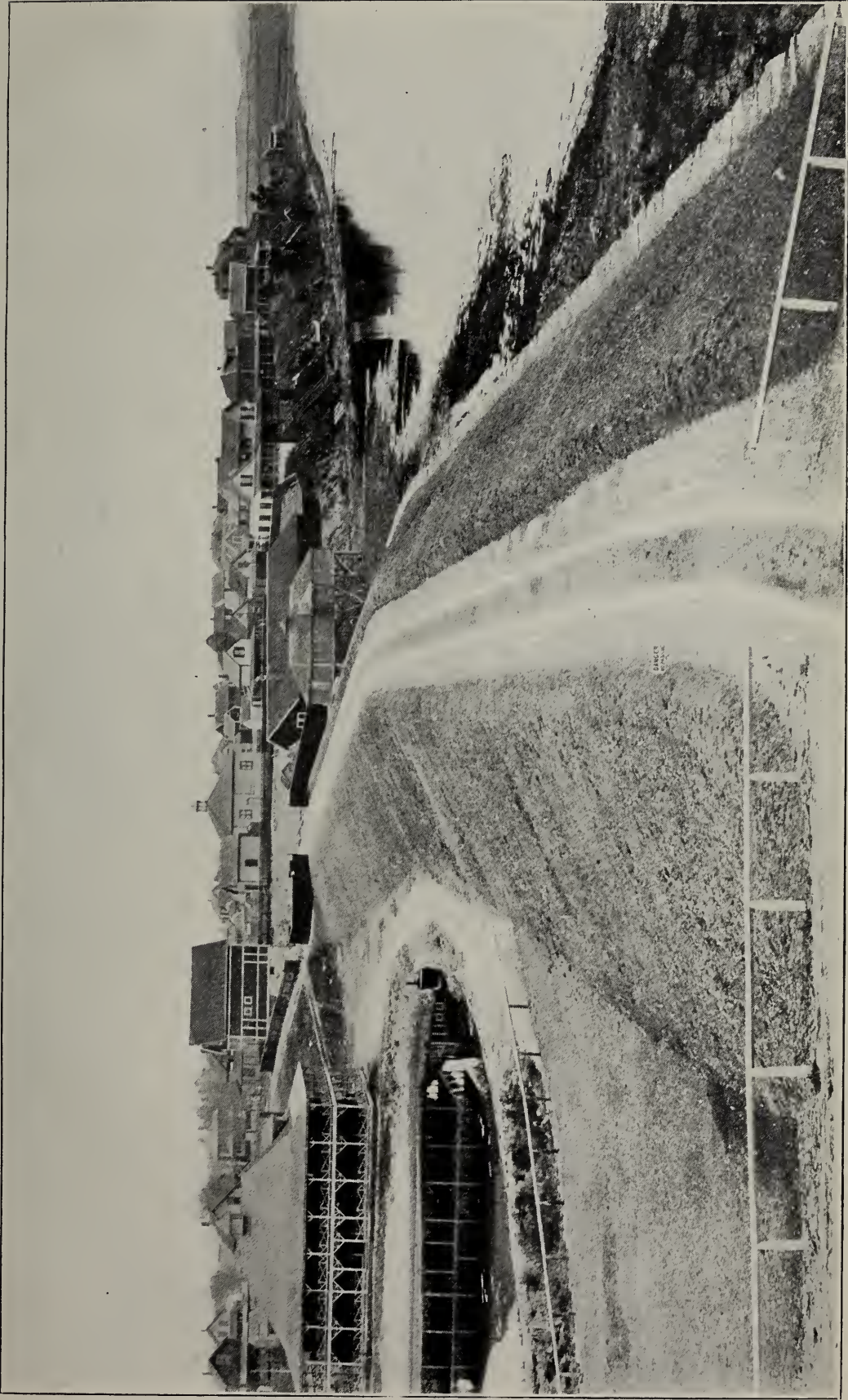
At this point penstock and check valves are introduced for controlling the sewage flow in the pipe.

The work of placing the pipe was begun in January and completed in August of this year. On August 14 the Quincy sewage was deflected from the Moon Island works, and since that date has been delivered to the High-level Sewer. The line was successfully placed through the park lands without injury to shrubbery or trees.

### GRADING ABOUT WARD STREET STATION.

At the beginning of the year the grounds about the station were in comparatively smooth condition, as left by contractors for the station buildings, and partially subgraded by day labor last year. Peat found in the excavations had been stored at the easterly end of the





HIGH-LEVEL SEWER—EMBANKMENT CONNECTING ISLAND AVENUE IN QUINCY WITH LOCKER AND OTHER SEWER BUILDINGS.



lot, and stones and bowlders found had been placed at convenient points near the locations of proposed roads.

All coal at this station is delivered by teams, usually in loads of from 8 to 10 tons. It was, therefore, necessary to provide a road surface to resist this heavy teaming. During the early portion of the year a road about 20 feet in width was constructed, extending from Ward Street, near the easterly borders of the lot around the station, to the rear of the station buildings, where it is widened to about 50 feet, from the screen house to the coal pocket. This provides ample street area for maneuvering the coal team. A narrow road is thence extended to Vancouver Street near the northwesterly corner of the station lot.

Branch roads also have been constructed back of the engine house through the arch at the end of the boiler house, uniting with the main road at the coal pocket, and from the barn at the easterly corner of the lot to the main road near Ward Street.

The bowlders and stones found in the early excavations were used in the form of Telford paving, about 18 inches in thickness, under the road surfaces. This pavement was covered with about 4 inches of broken stone and stone dust, and the whole rolled into shape by a 20-ton road roller.

Paths about 8 feet in width, of similar construction to the roads, were built to the doors on the Phillips, Ward and Vancouver street sides of the engine house. About 2,200 square yards of road surfaces were thus constructed.

The station lot has an area of 102,000 square feet. The buildings and lockers cover 36,000 square feet; the roads and paths cover about 20,000 square feet. The remaining area of about 45,000 square feet was covered during the early summer, about 1 foot in depth, with the most desirable of the peat stored from the excavations. This peat was further covered about 4 inches in depth with good quality of loam. All of the graded areas have been seeded. The bottom of the base course of the engine house buildings is about 2 feet above the adjacent street levels on Ward and Vancouver streets. The finished surface of the lot has been sloped evenly from this base course of the buildings to the sidewalk grades of adjacent streets.



### REVERSAL OF GRADE AT THE LOWER END OF THE CHARLES RIVER MAIN SEWER.

On October 14, 1904, when the Ward Street station was first put into operation, so much of the Charles River Metropolitan main sewer as was located above Vancouver Street had been diverted to this new pumping station. The length of the Metropolitan sewer below Vancouver Street, extending along Huntington Avenue to Gainsborough Street, has during the year remained tributary to the Boston Main Drainage Works, pending discussion with the city of Boston and other public officials, in relation to the disposal of sewage from this branch.

Early in December of this year the works for diverting the sewage from this branch to the new Ward Street station were begun. This length of sewer in Huntington Avenue varies in diameter from 5 feet 6 inches to 6 feet 6 inches. The last connection from the local sewerage systems with this sewer is located at Bryant Street, distant from Vancouver Street about 1,800 feet. The invert of this length of 1,800 feet is being regraded from Bryant Street to Vancouver Street by introducing a new concrete invert having an inclination towards Vancouver Street.

As the sewage from the districts tributary to this branch is comparatively small, the new invert diameter is reduced to about 3 feet, with an inclination towards Vancouver Street of 1 foot in 1,500 feet. At Bryant Street it is proposed to introduce a penstock valve, 40 inches in diameter. This under slight heads will admit of turning the whole flow of the existing Charles River main sewer, if desired, into its old connection with the Boston Main Drainage Works; or, under like conditions, the city of Boston works may find relief in case of accident through the South Metropolitan System.

At the date of this report, for a length of about 1,100 feet from Vancouver to Parker Street, work on the modified invert has been largely completed.

#### *Section 77, Ward Street Station and Connections.*

At the date of this report the only contract for the construction of any part of the High-level Sewer and appurtenances that has not been fully completed and adjusted is that for the pumps, boilers and connections, at the Ward Street station.

Under the contract between the E. P. Allis Company of Milwaukee and the Commonwealth, fully described in earlier reports, the plant was erected and put into operation as early as October, 1904. By arrangement between the Board and the engine builders, this pumping plant has been operated in the regular service of the station during the past year. The engine company have retained experts at the station during the year, studying the operation of the plant, and from time to time introducing minor modifications found essential to satisfy the rigorous tests required under the contract. It is probable that the engine company will arrange at an early date for completing the trials prescribed in the contract as a condition to final payments and adjustment of this contract.

## MAINTENANCE.

### SCOPE OF WORK AND FORCE EMPLOYED.

The maintenance of the Metropolitan Sewerage System includes the operation of seven stations and 96.12 miles of Metropolitan sewers, receiving the discharge from 1,013.31 miles of town and city sewers at 310 points, together with the care and study of inverted siphons under streams and in the harbor.

The permanent maintenance force of 118 men includes 68 engineers and other employés at the pumping stations, and 50 men employed on actual sewer maintenance and care of pumping station grounds. In the three following tables the use of the completed systems and other data are shown : —

NORTH METROPOLITAN SYSTEM.

Table showing Cities and Towns delivering Sewage in this System; Approximate Miles of Sewer connected; Estimated Populations and Areas now contributing; Total Areas ultimately to contribute, and Present Populations on Such Areas; Ratios of Present Contributing Areas to Ultimate Areas, and Ratios of Populations now contributing to Present Total Populations.

[Populations estimated as of December 31, 1905.]

CITIES AND TOWNS.	Miles of Local Sewer connected.	Separate or Combined.	Number of Connections with Local Sewers.	Estimated Number of Persons served by each House-connection. <sup>1</sup>	Estimated Population now contributing Sewage.	Estimated Present Total Population.	Estimated Area now contributing Sewage.	Area ultimately to contribute Sewage.	Ratio of Contributing to Present Total Population.	Ratio of Contributing Area to Ultimate Area.
Boston (Deer Island),	0.70	Separate,	-	-	1,275 <sup>2</sup>	1,275	Square Miles.	Square Miles.	Per Cent.	Per Cent.
Winthrop,	26.85	Separate,	1,758	4.0	7,030	7,140	1.23	1.61	98.5	76.4
Boston (East Boston),	21.49	Separate and combined,	5,169	9.3	48,070	52,000	0.77	2.18	92.4	35.3
Chelsea,	9.00 <sup>3</sup>	Separate and combined,	1,120	7.0	7,840	37,700	0.42	2.24	20.8	18.8
Everett,	41.55	Separate and combined,	3,858	6.0	23,150	29,770	1.85	3.34	77.8	55.4
Malden,	48.71	Separate,	4,429	5.6	24,800	38,610	2.59	5.07	64.3	51.1
Melrose,	32.87	Separate,	2,383	4.3	10,250	14,500	1.61	3.73	70.7	43.2
Boston (Charlestown),	21.08	Separate and combined,	5,108	7.8	39,840 <sup>4</sup>	40,000	0.67	1.27	99.6	52.8
Cambridge,	127.09 <sup>5</sup>	Separate and combined,	14,519	6.7	97,280	98,210	4.94	6.11	99.1	81.0
Somerville,	86.44	Separate and combined,	13,037	5.3	69,100	70,200	3.27	3.96	98.4	82.6
Medford,	48.72	Separate,	3,246	5.4	17,530	19,900	2.56	8.35	88.1	30.7
Winchester,	21.48	Separate,	927	5.3	4,910	8,400	1.07	5.95	58.5	18.0
Woburn,	12.88 <sup>6</sup>	Separate,	901	5.5	4,960	14,430	0.91	12.71	34.4	7.2
Stoneham,	11.04	Separate,	543	4.4	2,390	6,340	0.59	5.50	37.7	10.7
Arlington,	19.75	Separate,	939	6.1	5,730	9,820	1.65	5.20	58.4	31.7
Belmont,	9.15	Separate,	294	6.1	2,240 <sup>7</sup>	4,390	0.89	4.66	51.0	19.1
Wakefield,	11.20	Separate,	-	5.5	1,870	10,410	0.42	7.65	18.0	5.5
Lexington, <sup>8</sup>	-	-	-	-	-	2,800	-	5.11	-	-
Revere,	23.57	Separate,	1,630	5.1	8,310	12,950	1.40	5.86	64.2	23.9
Total's,	573.57	-	60,201	6.3	376,575	478,845 <sup>9</sup>	26.84	90.50	78.6	29.7

<sup>1</sup> Estimated from assessors' statement of the number of houses in each city or town, and the population from census of 1905.

<sup>2</sup> Estimated by Superintendent J. R. Gerrish of the Institution on Deer Island.

<sup>3</sup> Only the districts connecting at Cypress Street, Revere Beach Parkway, Springvale Avenue and Willoughby Street are now contributing sewage.

<sup>4</sup> Including 30 persons at Navy Yard.

<sup>5</sup> Revised in accordance with recent report of the City Engineer.

<sup>6</sup> Exclusive of Mystic River valley sewer and tanneries.

<sup>7</sup> Including 2 connections with McLean Hospital, having an estimated population of 448.

<sup>8</sup> Lexington not connected.

<sup>9</sup> It will be noted that the recent census returns do not fully justify all the published forecasts of earlier reports.



## SOUTH METROPOLITAN SYSTEM.

*Table showing Cities and Towns delivering Sewage to this System; Approximate Miles of Sewer connected; Estimated Populations and Areas now contributing; Total Areas ultimately to contribute, and Present Populations on Such Areas; Ratios of Present Contributing Areas to Ultimate Areas, and Ratios of Populations now contributing to Present Total Populations.*

[Populations estimated as of December 31, 1905.]

CITIES AND TOWNS.	Miles of Local Sewer connected.	Separate or Combined.	Number of Connections with Local Sewers.	Estimated Number of Persons served by each House-connection. <sup>1</sup>	Estimated Population now contributing Sewage.	Estimated Present Total Population.	Estimated Area now contributing Sewage.	Area ultimately to contribute Sewage.	Ratio of Contributing Population to Present Total Population.	Ratio of Contributing Area to Ultimate Area.
Boston (Back Bay),	21.97	Separate and combined,	1,497	14.2	21,260	21,300	Square Miles. 1.20	Square Miles. 1.61	Per Cent. 99.8	Per Cent. 74.5
Boston (Brighton),	53.22	Separate and combined,	2,610	5.5	14,360	22,400	3.16	3.74	64.1	84.5
Brookline, . . .	56.75	Separate and combined,	3,072	6.4	19,660	23,910	3.24	6.81	82.2	47.6
Newton, . . .	100.54	Separate, . . .	5,104	5.7	29,090	37,240	6.78	16.88	78.2	40.2
Watertown, . . .	31.60	Separate, . . .	1,621	5.1	8,270	11,420	1.78	4.04	72.5	44.1
Waltham, . . .	38.53	Separate, . . .	2,793	8.9 <sup>2</sup>	24,860	26,600	2.41	13.63	93.5	17.7
Boston (Dorchester),	15.93	Separate and combined,	1,213	6.4	7,760	41,700	.91	4.89	18.6	18.6
Milton, . . .	6.54	Separate and combined,	154	5.3	820	7,090	.35	12.59	11.6	2.8
Hyde Park, . . .	20.40	Separate, . . .	891	7.9 <sup>2</sup>	7,040	14,630	1.08	4.57	48.1	23.6
Dedham, . . .	14.11	Separate, . . .	329	5.2	1,710	7,400	.71	9.40	23.1	7.6
Boston (Roxbury),	-	-	-	-	-	31,800	-	1.23	-	-
Boston (West Roxbury),	33.89	Separate, . . .	1,818	6.5	11,820	27,000	1.80	8.92	43.8	20.2
Quincy, . . .	46.26	Separate, . . .	1,798	5.4	9,710	28,160	2.30	12.56	34.4	18.3
Totals, . . .	439.74	-	22,900	6.8	156,360	300,650 <sup>3</sup>	25.72	100.87	52.0	25.5

<sup>1</sup> Estimated from assessors' statement of the number of houses in each city or town, and the population from census of 1905.

<sup>2</sup> Estimated by City Engineer. <sup>3</sup> It will be noted that the recent census returns do not fully justify all the published forecasts of earlier reports.

WHOLE METROPOLITAN SYSTEM.

Table showing Areas delivering Sewage to the Entire System, inclusive of added High-level Area; Approximate Miles of Sewer connected; Estimated Populations and Areas now contributing; Total Areas ultimately to contribute, and Present Populations on Such Areas; Ratios of Present Contributing Areas to Ultimate Areas, and Ratios of Populations now contributing to Present Total Populations.

[Populations estimated as of December 31, 1905.]

SYSTEM.	Miles of Local Sewer connected.	Separate or Combined.	Number of Connections with Local Sewers.	Estimated Number of Persons served by each House-connection.	Estimated Population now contributing Sewage.	Estimated Present Total Population.	Estimated Area now contributing Sewage.	Area ultimately to contribute Sewage.	Ratio of Contributing Population to Present Total Population.	Ratio of Contributing Area to Ultimate Area.
North Metropolitan,	573.57	Separate and combined,	60,201	6.3	376,575	478,845	Square Miles. 26.80	Square Miles. 90.50	Per Cent. 78.6	Per Cent. 29.7
South Metropolitan,	439.74	Separate and combined,	22,900	6.8	156,360	300,650	25.72	100.87	52.0	25.5
Totals, . . .	1,013.31	- - -	83,101	6.4	532,935	779,495 <sup>1</sup>	52.52	191.37	68.4	27.4

<sup>1</sup> It will be noted that the recent census returns do not fully justify all the published forecasts of earlier reports.

CAPACITY AND RESULTS.

The following tables summarize the pumping records for the year for the Metropolitan Sewerage stations : —

NORTH METROPOLITAN SYSTEM.

*Deer Island Pumping Station.*

At this station are three submerged centrifugal pumps, with impellers or wheels 8.25 feet in diameter, driven by triple-expansion engines of the Reynolds-Corliss type.

Contract capacity of pumps: 45,000,000 gallons each, with 19-foot lift.  
Average duty for the year: 49,700,000 foot-pounds.  
Average quantity raised each day: 54,400,000 gallons.  
Force employed: 3 engineers, 3 firemen, 6 screenmen and 1 reliefman.  
Coal used: first-quality Cumberland, costing from \$3.44 to \$3.75 per ton.

*Table of Approximate Quantities, Lifts and Duties at the Deer Island Pumping Station of the North Metropolitan System.*

MONTHS.	Total Pumpage (Gallons).	Average per Day (Gallons).	Minimum Day (Gallons).	Maximum Day (Gallons).	Average Lift (Feet).	Average Duty (ft.-lbs. per 100 lbs. Coal).
<b>1905.</b>						
January, . . . .	2,084,200,000	67,200,000	52,900,000	119,000,000	10.89	46,300,000
February, . . . .	1,686,400,000	60,200,000	51,000,000	69,300,000	10.54	50,100,000
March, . . . .	2,123,800,000	68,500,000	47,800,000	102,000,000	10.94	49,200,000
April, . . . .	1,915,200,000	63,800,000	48,300,000	104,100,000	10.82	52,200,000
May, . . . .	1,532,300,000	49,400,000	43,800,000	67,600,000	10.46	48,900,000
June, . . . .	1,541,300,000	51,400,000	36,200,000	71,000,000	10.86	47,600,000
July, . . . .	1,437,700,000	46,400,000	41,600,000	53,200,000	10.30	51,400,000
August, . . . .	1,396,100,000	45,000,000	37,800,000	58,700,000	10.76	54,900,000
September, . . . .	1,763,500,000	58,800,000	45,400,000	126,600,000	10.77	51,000,000
October, . . . .	1,440,200,000	46,500,000	39,300,000	55,400,000	10.57	48,700,000
November, . . . .	1,319,000,000	44,000,000	34,100,000	64,200,000	10.01	41,000,000
December, . . . .	1,585,400,000	51,100,000	42,300,000	65,300,000	10.63	44,600,000
Total, . . . .	19,825,100,000	-	-	-	-	-
Average, . . . .	-	54,400,000	43,400,000	79,700,000	10.63	49,700,000



East Boston Pumping Station.

At this station are three submerged centrifugal pumps, with impellers or wheels 8.25 feet in diameter, driven by triple-expansion engines of the Reynolds-Corliss type.

Contract capacity of pumps: 45,000,000 gallons each, with 19-foot lift.  
Average duty for the year: 55,800,000 foot-pounds.  
Average quantity raised each day: 52,400,000 gallons.  
Force employed: 3 engineers, 3 firemen, 6 screenmen and 1 reliefman.  
Coal used: first-quality Cumberland, costing from \$3.30 to \$3.60 per ton.

Table of Approximate Quantities, Lifts and Duties at the East Boston Pumping Station of the North Metropolitan System.

MONTHS.	Total Pumpage (Gallons).	Average per Day (Gallons).	Minimum Day (Gallons).	Maximum Day (Gallons).	Average Lift (Feet).	Average Duty (ft.-lbs. per 100 lbs. Coal).
<b>1905.</b>						
January, . . . .	2,022,200,000	65,200,000	50,900,000	117,000,000	16.71	56,500,000
February, . . . .	1,630,400,000	58,200,000	49,000,000	67,300,000	16.56	53,000,000
March, . . . .	2,061,800,000	66,500,000	45,800,000	100,000,000	16.48	58,700,000
April, . . . .	1,855,200,000	61,800,000	46,300,000	102,100,000	16.53	52,700,000
May, . . . .	1,470,300,000	47,400,000	41,800,000	65,600,000	16.07	55,000,000
June, . . . .	1,481,300,000	49,400,000	34,200,000	69,000,000	16.02	59,300,000
July, . . . .	1,375,700,000	44,400,000	39,600,000	51,200,000	16.06	58,300,000
August, . . . .	1,334,100,000	43,000,000	35,800,000	56,700,000	16.02	58,100,000
September, . . . .	1,703,500,000	56,800,000	43,400,000	124,600,000	16.19	58,000,000
October, . . . .	1,378,200,000	44,500,000	37,300,000	53,400,000	16.00	54,900,000
November, . . . .	1,259,000,000	42,000,000	32,100,000	62,200,000	16.01	51,500,000
December, . . . .	1,523,400,000	49,100,000	40,300,000	63,300,000	16.01	53,900,000
Total, . . . .	19,095,100,000	-	-	-	-	-
Average, . . . .	-	52,400,000	41,400,000	77,700,000	16.23	55,800,000

Charlestown Pumping Station.

At this station are three submerged centrifugal pumps, two of them having impellers or wheels 7.5 feet in diameter, the other 8.25 feet in diameter. They are driven by triple-expansion engines of the Reynolds-Corliss type.

Contract capacity of pumps: two, 22,000,000 gallons each, with 11-foot lift; one, 60,000,000 gallons, with 8-foot lift.  
Average duty for the year: 43,100,000 foot-pounds.  
Average quantity raised each day: 29,900,000 gallons.  
Force employed: 3 engineers, 3 firemen, 6 screenmen and 1 reliefman.  
Coal used: first quality Cumberland, costing from \$3.45 to \$3.60 per ton.

Table of Approximate Quantities, Lifts and Duties at the Charlestown Pumping Station of the North Metropolitan System.

MONTHS.	Total Pumpage (Gallons).	Average per Day (Gallons).	Minimum Day (Gallons).	Maximum Day (Gallons).	Average Lift (Feet).	Average Duty (ft.-lbs. per 100 lbs. Coal).
<b>1905.</b>						
January, . . . . .	1,063,900,000	34,300,000	27,900,000	66,700,000	8.11	46,100,000
February, . . . . .	889,400,000	31,800,000	27,100,000	37,100,000	7.93	43,000,000
March, . . . . .	1,085,700,000	35,000,000	26,500,000	49,600,000	8.17	48,500,000
April, . . . . .	931,700,000	31,100,000	22,600,000	48,200,000	7.92	44,100,000
May, . . . . .	882,900,000	28,500,000	22,800,000	54,000,000	7.74	42,000,000
June, . . . . .	922,200,000	30,700,000	21,000,000	43,100,000	7.93	44,300,000
July, . . . . .	876,100,000	28,300,000	23,000,000	32,200,000	7.80	44,800,000
August, . . . . .	838,200,000	27,000,000	22,800,000	41,200,000	7.63	41,800,000
September, . . . . .	913,900,000	30,500,000	23,600,000	61,600,000	7.88	47,000,000
October, . . . . .	878,000,000	28,300,000	21,800,000	40,000,000	7.78	43,900,000
November, . . . . .	754,300,000	25,100,000	20,500,000	40,000,000	7.62	34,800,000
December, . . . . .	863,000,000	27,800,000	22,100,000	39,800,000	7.63	37,400,000
Total, . . . . .	10,899,300,000	-	-	-	-	-
Average, . . . . .	-	29,900,000	23,500,000	46,100,000	7.85	43,100,000

*Alewife Brook Pumping Station.*

The plant at this station consists of the original installation of small commercial pumps and engines, *i.e.*, two 9-inch Andrews vertical centrifugal pumps, with direct-connected compound marine engines, together with the recent additions. The latter consists of a specially designed engine of the vertical cross-compound type, having between the cylinders a centrifugal pump rotating on a horizontal axis.

Contract capacity of the two original pumps: 4,500,000 gallons each, with 13-foot lift.  
Contract capacity of new pump: 13,000,000 gallons, with 13-foot lift.  
Average duty for the year: 17,000,000 foot-pounds.  
Average quantity raised each day: 3,234,000 gallons.  
Force employed: 3 engineers.  
Coal used: first quality Cumberland, costing from \$3.60 to \$4.65 per ton.

*Table of Approximate Quantities, Lifts and Duties at the Alewife Brook Pumping Station of the North Metropolitan System.*

MONTHS.	Total Pumpage (Gallons).	Average per Day (Gallons).	Minimum Day (Gallons).	Maximum Day (Gallons).	Average Lift (Feet).	Average Duty (ft.-lbs. per 100 lbs. Coal).
<b>1905.</b>						
January, . . . .	140,596,000	4,535,000	2,786,000	7,993,000	13.17	20,200,000
February, . . . .	105,312,000	3,761,000	3,179,000	4,201,000	13.35	18,800,000
March, . . . .	151,633,000	4,891,000	3,279,000	7,462,000	13.09	22,400,000
April, . . . .	119,141,000	3,971,000	2,692,000	7,049,000	13.25	20,400,000
May, . . . .	88,640,000	2,859,000	2,288,000	3,862,000	13.25	16,100,000
June, . . . .	87,863,000	2,929,000	2,330,000	4,260,000	13.25	16,200,000
July, . . . .	74,095,000	2,390,000	2,036,000	3,379,000	13.32	15,000,000
August, . . . .	67,907,000	2,191,000	1,826,000	3,179,000	13.18	14,300,000
September, . . . .	106,990,000	3,566,000	2,120,000	7,226,000	13.06	18,100,000
October, . . . .	76,619,000	2,472,000	1,994,000	3,862,000	13.24	14,700,000
November, . . . .	69,166,000	2,306,000	1,784,000	4,435,000	13.20	14,000,000
December, . . . .	90,934,000	2,933,000	2,372,000	4,615,000	12.21	14,300,000
Total, . . . .	1,178,896,000	-	-	-	-	-
Average, . . . .	-	3,234,000	2,391,000	5,127,000	13.13	17,000,000



*Ward Street Pumping Station.*

At this station are two vertical, triple-expansion pumping engines, of the Allis-Chalmers type, operating reciprocating pumps, the plungers of which are 48 inches in diameter with a 60-inch stroke.

Contract capacity of pumps: 50,000,000 gallons each, with 45-foot lift.  
 Average duty for the year: 89,700,000 foot-pounds.  
 Average quantity raised each day: 20,940,000 gallons.  
 Force employed: 3 engineers, 3 firemen, 3 oilers, 3 screenmen and 1 reliefman.  
 Coal used: first quality Cumberland, costing from \$4.10 to \$4.28 per ton.

*Table of Approximate Quantities, Lifts and Duties at the Ward Street Pumping Station of the South Metropolitan System.*

MONTHS.	Total Pumpage (Gallons).	Average per Day (Gallons).	Minimum Day (Gallons).	Maximum Day (Gallons).	Average Lift (Feet).	Average Duty (ft.-lbs. per 100 lbs. Coal).
<b>1905.</b>						
January, . . . .	841,600,000	27,200,000	20,340,000	34,260,000	39.70	74,900,000
February, . . . .	598,800,000	21,400,000	18,040,000	22,950,000	39.40	69,000,000
March, . . . .	779,800,000	25,200,000	17,710,000	34,700,000	41.00	102,100,000
April, . . . .	724,000,000	24,100,000	17,770,000	36,170,000	41.60	114,200,000
May, . . . .	612,100,000	19,700,000	16,730,000	24,070,000	41.20	86,600,000
June, . . . .	589,000,000	19,600,000	15,170,000	21,360,000	40.30	89,800,000
July, . . . .	514,200,000	16,590,000	12,840,000	21,470,000	40.00	73,200,000
August, . . . .	481,800,000	15,540,000	12,140,000	21,560,000	39.37	69,800,000
September, . . . .	708,100,000	23,600,000	17,670,000	55,250,000	40.02	91,300,000
October, . . . .	559,200,000	18,000,000	14,720,000	25,950,000	40.14	85,500,000
November, . . . .	548,100,000	18,300,000	15,650,000	24,040,000	40.10	108,500,000
December, . . . .	685,100,000	22,100,000	16,500,000	32,200,000	40.34	111,000,000
Total, . . . .	7,641,800,000	-	-	-	-	-
Average, . . . .	-	20,940,000	16,270,000	29,500,000	40.26	89,700,000

Records from plunger displacement.  
 Average slip for the year about 11 per cent.

*Quincy Pumping Station.*

At this station are two compound condensing Deane pumping engines.

Contract capacity of pumps: one, 3,000,000 gallons, the other, 5,000,000 gallons, with 36-foot lift.

Average duty for the year: 32,800,000 foot-pounds.

Average quantity raised each day: 3,180,000 gallons.

Force employed: 3 engineers and 1 screenman.

Coal used: first-quality Cumberland, costing from \$4.20 to \$4.75 per ton.

*Table of Approximate Quantities, Lifts and Duties at the Quincy Pumping Station of the South Metropolitan System.*

MONTHS.	Total Pumpage (Gallons).	Average per Day (Gallons).	Minimum Day (Gallons).	Maximum Day (Gallons).	Average Lift (Feet).	Average Duty (ft.-lbs. per 100 lbs. Coal).
<b>1905.</b>						
January, . . . .	108,877,000	3,512,000	2,881,000	4,973,000	35.60	34,600,000
February, . . . .	87,534,000	3,126,000	2,969,000	3,315,000	36.74	31,600,000
March, . . . .	110,443,000	3,563,000	3,011,000	4,132,000	38.29	38,000,000
April, . . . .	120,031,000	4,001,000	3,387,000	5,059,000	38.22	40,700,000
May, . . . .	101,670,000	3,280,000	2,834,000	3,565,000	38.83	27,200,000
June, . . . .	90,273,000	3,009,000	2,825,000	3,281,000	39.62	37,900,000
July, . . . .	84,559,000	2,728,000	2,491,000	2,940,000	38.38	35,300,000
August, . . . .	82,913,000	2,675,000	2,458,000	2,998,000	33.18	32,400,000
September, . . . .	97,222,000	3,241,000	2,620,000	3,891,000	22.04	31,300,000
October, . . . .	92,323,000	2,978,000	2,778,000	3,190,000	22.00	30,600,000
November, . . . .	86,213,000	2,874,000	2,708,000	3,165,000	21.80	26,000,000
December, . . . .	98,444,000	3,176,000	2,934,000	3,315,000	21.42	28,200,000
Total, . . . .	1,160,502,000	-	-	-	-	-
Average, . . . .	-	3,180,000	2,825,000	3,652,000	32.18	32,800,000

Nut Island Screen House.

The plant at the house includes two sets of screens in duplicate, actuated by small reversing engines of the Fitchburg type. Two vertical Deane boilers, 80 horse-power each, operate the engines, provide heat for the house and burn materials intercepted at the screens.

Average quantity of sewage passing screens daily, 25,000,000 gallons.  
Total materials intercepted at screens during the past year, 543 cubic yards.  
Materials intercepted per million gallons of sewage discharge, 1.6 cubic feet.  
Force employed: 3 engineers and 3 screenmen.  
Coal used: 281 tons first quality Cumberland, costing from \$3.59 to \$6.35 per ton.

In the following tables the total cost of pumping and the rate per million foot-gallons at each of six pumping stations are shown in detail: —

Average Cost per Million Foot-gallons for Pumping at the Deer Island Station.

Volume (19,825 Million Gallons) × Lift (10.63 Feet) = 210,741 Million Foot gallons.

ITEMS.	Cost.	Cost per Million Foot-gallons.
Labor, . . . . .	\$9,228 20	\$0.04379
Coal, . . . . .	6,035 26	.02864
Oil, . . . . .	196 08	.00093
Waste, . . . . .	76 57	.00036
Water, . . . . .	1,018 80	.00483
Packing, . . . . .	343 28	.00163
Miscellaneous supplies and renewals, . . . . .	1,475 28	.00700
Totals, . . . . .	\$18,373 47	\$0.08718

Average Cost per Million Foot-gallons for Pumping at the East Boston Station.

Volume (19,095 Million Gallons) × Lift (16.23) = 309,913 Million Foot-gallons.

ITEMS.	Cost.	Cost per Million Foot-gallons.
Labor, . . . . .	\$8,689 89	\$0.02803
Coal, . . . . .	7,455 52	.02406
Oil, . . . . .	256 69	.00083
Waste, . . . . .	61 43	.00019
Water, . . . . .	1,056 60	.00341
Packing, . . . . .	48 56	.00016
Miscellaneous supplies and renewals, . . . . .	948 33	.00306
Totals, . . . . .	\$18,517 02	\$0.05974



*Average Cost per Million Foot-gallons for Pumping at the Charlestown Station.*

Volume (10,899 Million Gallons)  $\times$  Lift (7.85 Feet) = 85,559 Million Foot-gallons.

ITEMS.	Cost.	Cost per Million Foot-gallons.
Labor, . . . . .	\$8,599 81	\$0.10051
Coal, . . . . .	2,768 54	.03235
Oil, . . . . .	169 90	.00199
Waste, . . . . .	71 02	.00083
Water, . . . . .	405 60	.00474
Packing, . . . . .	180 05	.00210
Miscellaneous supplies and renewals, . . . . .	961 29	.01124
Totals, . . . . .	\$13,166 21	\$0.15376

*Average Cost per Million Foot-gallons for Pumping at the Alewife Brook Station.*

Volume (1,178,896 Million Gallons)  $\times$  Lift (13.13 Feet) = 15,479 Million Foot-gallons.

ITEMS.	Cost.	Cost per Million Foot-gallons.
Labor, . . . . .	\$3,296 89	\$0.21299
Coal, . . . . .	1,521 16	.09827
Oil, . . . . .	68 58	.00444
Waste, . . . . .	38 22	.00247
Water, . . . . .	150 48	.00972
Packing, . . . . .	41 56	.00270
Miscellaneous supplies and renewals, . . . . .	138 16	.00893
Totals, . . . . .	\$5,255 15	\$0.33952

*Average Cost per Million Foot-gallons for Pumping at the Ward Street Station.*

Volume (7,642 Million Gallons)  $\times$  Lift (40.26 Feet) = 307,659 Million Foot-gallons.

ITEMS.	Cost.	Cost per Million Foot-gallons.
Labor, . . . . .	\$10,946 61	\$0.03558
Coal, . . . . .	7,052 50	.02292
Oil, . . . . .	632 27	.00206
Waste, . . . . .	88 83	.00029
Water, . . . . .	1,117 20	.00363
Packing, . . . . .	287 24	.00093
Miscellaneous supplies and renewals, . . . . .	267 82	.00087
Totals, . . . . .	\$20,392 47	\$0.06628

Average Cost per Million Foot-gallons for Pumping at the Quincy Station.

Volume (1,160 Million Gallons) × Lift (32.18 Feet) = 37,345 Million Foot-gallons.

ITEMS.	Cost.	Cost per Million Foot-gallons.
Labor, . . . . .	\$3,581 19	\$0.09590
Coal, . . . . .	1,943 14	.05203
Oil, . . . . .	30 22	.00081
Waste, . . . . .	11 41	.00031
Water, . . . . .	178 42	.00478
Packing, . . . . .	40 03	.00107
Miscellaneous supplies and renewals, . . . . .	581 98	.01558
Totals, . . . . .	\$6,366 39	\$0.17048

CARE OF SPECIAL STRUCTURES.

During the year the sea has encroached on the right of way for the outfall sewer at the southerly end of Deer Island, exposing the sheathing used for the original trench excavation. It has been found necessary to defend this section of the sewer by placing heavy riprap slopes on the easterly side of the embankment from the man-hole near the high-water line for a distance of about 200 feet north-erly. This work has involved the placing of 350 tons of stone.

OVERFLOW AT MALDEN.

During the years 1900 and 1901 a Metropolitan main sewer was constructed in the valleys of Spot Pond and Ell Pond brooks, from Wakefield through Melrose and Malden to near Barrett's Pond. At this point it was connected with the original Metropolitan sewer.

This construction was adequate until last spring, when the Metro-politan sewer below Barrett's Pond became surcharged, and acted as a pipe under pressure.

The new sewer should be extended to the tidal reaches of the Malden River below Charles Street, where an ample overflow from the sewer to the river should be provided from this branch of the Metropolitan sewer, until such time as the works are more compre-hensively relieved.

MATERIAL INTERCEPTED AT THE SCREENS.

The material intercepted at the screens at the North Metropolitan sewerage stations, consisting of rags, paper and other floating mat-

ters, has during the year amounted to 2,018 cubic yards. This is equivalent to 2.7 cubic feet for each million gallons of sewage pumped at Deer Island.

#### SOUTH METROPOLITAN OUTFALLS.

The 60-inch outlet pipes in the harbor have been in operation fourteen months at the date of this report. During the past year the average flow through them has been 25,000,000 gallons of sewage per day, with a maximum of 78,000,000 gallons during heavy storm.

The diving contractor who placed these pipes in the harbor has recently examined the outlets, and found no deposits on the bed of the harbor in the vicinity of the outlets either of sand or any materials from the sewage discharge. He penetrated the pipes for a length of 50 feet, and found them clean and in normal condition. A recent examination of the shores of the harbor and islands in the vicinity of the outfalls fails to disclose any trace of deposit attributable to this sewage discharge.

#### ADDITIONAL PUMPS AT QUINCY STATION.

An examination of the yearly records at this station indicates that the average sewage flow during dry weather equals and for much of the time exceeds the capacity of the smaller of the two pumps, and the sewage flow during very wet conditions exceeds the capacity of the larger pump. Additional pumping plant at this station should be introduced during the coming season.

#### MATERIAL INTERCEPTED AT THE SCREENS, SOUTH METROPOLITAN SYSTEM.

The material intercepted at the screens at the stations of this system has amounted to 1,986 cubic yards, equal to 5.9 cubic feet per million gallons of sewage delivered at the outfall works at Nut Island.

Studies of sewage flows in the Metropolitan sewers, siphons and outfall pipes indicate they are satisfactorily free from deposit, and in normal condition.

Respectfully submitted,

WM. M. BROWN,  
*Engineer Sewerage Works.*



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# APPENDIX.

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APPENDIX No. 1.

CONTRACTS MADE AND PENDING DURING

*Contracts relating to the Dam*

[NOTE. — The details of contracts made before

1.	2.	3.	AMOUNT OF BID.		6.	
			4.	5.		
Num- ber of Con- tract.	WORK.	Num- ber of Bids.	Next to Low- est.	Lowest.	Contractor.	
1	195	Wachusett Dam, . . .	11	\$1,680,870 00	\$1,603,635 00 <sup>1</sup>	McArthur Brothers Company.
2	245	Section 2 of relocation of Central Massachusetts Railroad (extension of Contract No. 195).	- <sup>2</sup>	- <sup>2</sup>	- <sup>2</sup>	McArthur Brothers Company.
3	257 <sup>3</sup>	Excavating soil, . . .	6	449,300 00	414,987 50 <sup>1</sup>	Bruno, Salomone & Petitti.
4	282 <sup>3</sup>	Building a part of Newton Street and improving Crescent Street, West Boylston, Mass.	8	4,508 75	4,496 43 <sup>1</sup>	Newell & Snowling Con- struction Co., Ux- bridge, Mass. (by assignment from Mc- Bride & Co.).
5	283 <sup>3</sup>	Stillwater River Improve- ment, West Boylston and Sterling, Mass.	8	25,500 00	25,461 25 <sup>1</sup>	McBride & Co., Brighton, Mass.
6	284 <sup>3</sup>	Riprap at South Dike, Boylston, Mass.	- <sup>2</sup>	- <sup>2</sup>	- <sup>2</sup>	McArthur Brothers Co., Chicago, Ill.
7	285 <sup>3</sup>	Surfacing highways with broken stone (Section 1), West Boylston, Mass.	6	7,254 09	7,211 92 <sup>1</sup>	The H. Gore Co., Boston, Mass.
8	286 <sup>3</sup>	Surfacing highways with broken stone (Section 2), West Boylston and Boyl- ston, Mass.	5	9,563 70	9,360 95 <sup>1</sup>	The H. Gore Co., Boston, Mass.
9	289	Brass railing posts, Wa- chusett Dam, Clinton, Mass.	4	5,780 00	4,150 00 <sup>1</sup>	J. H. McCafferty & Co., Boston, Mass.
10	290 <sup>3</sup>	Brass tubing for railing, Wachusett Dam, Clin- ton, Mass.	4	2,165 45	2,165 45 <sup>1</sup>	American Tube Works, Boston, Mass.
11	291	Granite posts, curbing and edgestones for Wachu- sett Dam.	6	1,741 00	1,700 00 <sup>1</sup>	F. A. McCauliff, Fitch- burg, Mass.
		Total, . . . . .				

<sup>1</sup> Contract based upon this bid.      <sup>2</sup> Competitive bids were not received on this contract.

## APPENDIX No. 1.

## THE YEAR 1905 — WATER WORKS.

*and Reservoir Department.*

1905 have been given in previous reports.]

7. Date of Contract.	8. Date of Completion of Work.	9. Prices of Principal Items of Contracts made in 1905.	10. Value of Work done Decem- ber 31, 1905.	
Oct. 1, '00,	-	-	\$1,569,790 00	1
April 18, '02,	-	-	282,390 00	2
Dec. 27, '02,	Nov. 11, '05,	-	543,680 45	3
April 21, '05,	July 6, '05,	For earth excavation, \$0.18¾ per cubic yard, . . .	4,812 25	4
May 15, '05,	Nov. 11, '05,	For clearing and grubbing, \$53 per acre; for earth excavation, \$0.19⅞ per cubic yard.	28,181 69	5
May 4, '05,	Nov. 21, '05,	For riprap, \$1.25 per cubic yard, . . . . .	15,385 24	6
May 23, '05,	Nov. 9, '05,	For shaping roadbed, \$0.045 per linear foot; for broken stone in place, \$1.73 per ton.	7,856 09	7
May 23, '05,	Nov. 4, '05,	For shaping road-bed, \$0.045 per linear foot; for broken stone in place, \$1.73 per ton.	9,790 48	8
Sept. 8, '05,	-	For brasswork, \$4,150, . . . . .	1,700 00	9
Sept. 7, '05,	Nov. 3, '05,	-	2,192 06	10
Dec. 12, '05,	-	For whole work, \$1,700, . . . . .	-	11
. . . . .	. . . . .	. . . . .	\$2,465,778 26	

<sup>3</sup> Contract completed.



CONTRACTS MADE AND PENDING DURING THE  
*Contracts relating to the*

1. Num- ber of Con- tract.	2.  WORK.	3.  Num- ber of Bids.	AMOUNT OF BID.		6.  Contractor.	
			4. Next to Low- est.	5. Lowest.		
1	287 <sup>3</sup>	Cast-iron water pipes and special castings.	3	\$2,017 74	\$1,991 80 <sup>1</sup>	Warren Foundry and Machine Co., New York, N. Y.
2	288	Pumping engine for the Arlington station.	7	7,900 00	7,830 00	Allis-Chalmers Co., Milwaukee, Wis.
3	292 <sup>3</sup>	41.5 tons special castings, .	4	69 00 per ton.	57 50 <sup>1</sup> per ton.	R. D. Wood & Co., Philadelphia, Pa.
4	Special Order. <sup>3</sup>	2 36-inch special foot valves.	- <sup>2</sup>	- <sup>2</sup>	- <sup>2</sup>	Coffin Valve Co., Bos- ton.
5	Special Order. <sup>3</sup>	Repairs on Upham house in Weston.	3	\$1,325 00	\$874 00 <sup>1</sup>	H. L. Cooper, Weston, Mass.
6	Special Order. <sup>3</sup>	36-inch valve, . . .	- <sup>2</sup>	- <sup>2</sup>	- <sup>2</sup>	Chapman Valve Mfg. Co., Indian Orchard, Mass.
7	Special Order. <sup>3</sup>	Changing 36-inch gate from geared to hydrau- lic.	- <sup>2</sup>	- <sup>2</sup>	- <sup>2</sup>	Coffin Valve Co., Bos- ton.
		Total, . . . . .				

<sup>1</sup> Contract based upon this bid.      <sup>2</sup> Competitive bids were not received on this contract.

YEAR 1905 — WATER WORKS — *Continued.*

*Distribution Department.*

7.	8.	9.	10.	
Date of Contract.	Date of Completion of Work.	Prices of Principal Items of Contracts made in 1905.	Value of Work done Decem- ber 31, 1905.	
April 28, '05,	July 18, '05,	For 48-inch cast-iron pipe, \$26 per ton of 2,000 pounds; for special castings, \$0.02 $\frac{3}{4}$ per pound.	\$2,122 33	1
Oct. 28, '05,	-	For whole work, \$9,790, . . . . .	-	2
Mar. 6, '05,	Dec. 30, '05,	For all castings, \$57.50 per ton of 2,000 pounds, .	2,279 27	3
Mar. 6, '05,	July 21, '05,	For each valve, \$493, . . . . .	986 00	4
Mar. 29, '05,	June 16, '05,	For whole work, \$874, . . . . .	914 07	5
May 8, '05,	Sept. 20, '05,	For one 36-inch hydraulic valve, \$751.51, . . .	751 51	6
June 14, '05,	Nov. 20, '05,	For whole work, \$687, . . . . .	687 00	7
. . . . .	. . . . .	. . . . .	\$7,740 18	

<sup>3</sup> Contract completed.

CONTRACTS MADE AND PENDING DURING THE YEAR 1905 — WATER WORKS —

Concluded.

Summary of Contracts.<sup>1</sup>

	Value of Work done Decem- ber 31, 1905.
Wachusett Reservoir, 6 contracts, . . . . .	\$609,706 20
Relocation of Central Massachusetts Railroad, 1 contract, . . . . .	282,390 00
Wachusett Dam, 4 contracts, . . . . .	1,573,682 06
Distribution Department, 3 contracts, . . . . .	4,401 60
Total of 14 contracts made and pending during the year 1905, . . . . .	\$2,470,179 86
273 contracts completed from 1896 to 1904, inclusive, . . . . .	13,100,481 31
	\$15,570,661 17
Deduct for work done on 11 Sudbury Reservoir contracts by the city of Boston, . . . . .	512,000 00
Total of 293 contracts, . . . . .	\$15,058,661 17

<sup>1</sup> In this summary, contracts charged to maintenance are excluded.



## APPENDIX No. 2.

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### CEMENT TESTS — WATER WORKS.

The following tables contain : —

1. Tests of cements used in the construction of the Wachusett Dam and other works at the Wachusett Reservoir during the years 1901 to 1905, inclusive.

2. Tests of cements used in the construction of the Weston Aqueduct during the years 1901 to 1903, inclusive.

The methods of testing were the same as described in Appendix No. 3 of the annual report of the year 1897.

Summary of Tests of Cement used in the Construction of the Wachusett Dam

BRAND.		NUMBER OF BARRELS USED.		Composition of Briquette.	FINENESS.			WIRE TESTS.		TENSILE STRENGTH.	
		At Dam.	Totals.		Per Cent. Residue on No. 50 Sieve, 2,500 Meshes to Square Inch.	Per Cent. Residue on No. 100 Sieve, 10,000 Meshes to Square Inch.	Per Cent. Residue on No. 180 Sieve, 32,400 Meshes to Square Inch.	Minutes to Bear Light Wire.	Minutes to Bear Heavy Wire.	ONE DAY.	
										Number of Briquettes.	Pounds per Square Inch
	Portland cement :—										
1	Alpha, . . .	150	491	{ Neat, .	.4	10.9	28.6	158	347	47	694
				{ 2 to 1, .	-	-	-	-	316	-	-
2	Alsen, . . .	225	355	{ Neat, .	.4	11.2	26.4	116	291	31	625
				{ 2 to 1, .	-	-	-	-	306	-	-
3	Atlas, . . .	3,064	3,763	{ Neat, .	.2	9.0	22.4	113	354	207	571
				{ 2 to 1, .	-	-	-	-	287	-	-
4	Catekill, . .	-	305	{ Neat, .	.4	7.0	22.3	130	300	10	476
				{ 2 to 1, .	-	-	-	-	298	-	-
5	Giant, . . .	65,809	70,704	{ Neat, .	.5	8.7	21.9	140	380	4,088	586
				{ 2 to 1, .	-	-	-	-	383	-	-
6	Helderberg, .	200	212	{ Neat, .	.2	5.0	19.9	173	480	23	383
				{ 2 to 1, .	-	-	-	-	450	-	-
7	Iron Clad, . .	4,260	4,540	{ Neat, .	.1	4.2	17.1	86	304	222	652
				{ 2 to 1, .	-	-	-	-	293	-	-
8	Lehigh, . . .	7,245	14,075	{ Neat, .	.1	8.2	22.0	217	484	975	523
				{ 2 to 1, .	-	-	-	-	481	-	-
9	Star, . . .	-	1,200	{ Neat, .	.5	9.8	24.4	154	336	51	691
				{ 2 to 1, .	-	-	-	-	356	-	-
10	Stettin-Girstow, .	-	2,200	{ Neat, .	.7	8.3	21.3	62	178	252	377
				{ 2 to 1, .	-	-	-	-	351	-	-
11	Whitehall, . .	150	150	{ Neat, .	.3	8.3	27.5	180	360	20	736
				{ 2 to 1, .	-	-	-	-	450	-	-
	Total, . . .	81,103	97,995	{ Neat, .	.4	8.4	21.8	144	381	5,926	571
				{ 2 to 1, .	-	-	-	-	384	-	-
	Natural cement :—										
12	Union, . . .	182,480	182,480	{ Neat, .	.9	6.2	13.6	65	131	7,070	173
				{ 1 to 1, .	-	-	-	56	110	-	-
				{ 2 to 1, .	-	-	-	-	-	-	-

Summary of Tests of Cement used in the Construction

	Portland cement :—										
13	Atlas, . . .	-	91,875	{ Neat, .	.2	9.4	20.0	58	331	4,356	423
				{ 2 to 1, .	-	-	-	-	417	-	-
14	Giant, . . .	-	7,653	{ Neat, .	.3	9.5	20.7	69	303	430	420
				{ 2 to 1, .	-	-	-	-	366	-	-
15	Saylor's, . .	-	2,200	{ Neat, .	.2	6.2	18.0	161	479	127	214
				{ 2 to 1, .	-	-	-	-	544	-	-
16	Lehigh, . . .	-	5,160	{ Neat, .	.1	9.7	20.8	134	344	207	374
				{ 2 to 1, .	-	-	-	-	515	-	-
	Total, . . .	-	106,888	{ Neat, .	.2	9.4	20.0	65	333	5,120	415
				{ 2 to 1, .	-	-	-	-	420	-	-
	Natural cement :—										
17	Hoffman, . .	-	98,347	{ Neat, .	1.1	6.8	-	27	61	4,485	138
				{ 1 to 1, .	-	-	-	26	63	-	-
18	Union, . . .	-	14,738	{ Neat, .	1.0	6.8	13.1	40	90	832	157
				{ 1 to 1, .	-	-	-	27	73	-	-
	Total, . . .	-	113,085	{ Neat, .	1.1	6.8	-	29	65	5,317	141
				{ 1 to 1, .	-	-	-	26	64	-	-

and Other Works at the Wachusett Reservoir, 1901 to 1905, Inclusive.

TENSILE STRENGTH — Concluded.																	
SEVEN DAYS.		TWENTY-EIGHT DAYS.		THREE MONTHS.		SIX MONTHS.		NINE MONTHS.		ONE YEAR.		EIGHTEEN MONTHS.		TWO YEARS.		THREE YEARS.	
Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.
47	1,021	5	1,026	5	1,029	5	1,091	5	1,063	5	1,015	5	1,029	5	1,034	5	847
47	474	5	428	5	445	5	405	5	452	5	406	5	340	5	320	5	310
32	776	15	753	5	761	5	834	5	723	5	813	5	825	5	824	5	788
32	373	15	433	5	413	5	447	5	380	5	393	5	381	5	382	5	335
206	837	167	848	20	801	20	848	20	823	20	899	20	873	20	842	14	837
207	384	167	450	20	444	20	445	20	459	20	422	20	404	20	365	15	353
10	855	10	903	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10	393	10	477	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4,029	849	3,811	873	381	819	310	878	325	862	305	860	285	875	215	870	145	897
4,094	400	3,816	451	405	462	310	452	304	447	300	428	285	391	215	387	145	379
23	843	23	933	5	906	5	881	5	872	5	897	5	870	5	896	5	783
23	301	23	409	5	377	5	380	5	402	5	386	5	389	5	372	5	325
218	700	221	712	25	714	25	788	25	769	25	807	25	885	25	851	25	806
218	403	222	451	25	474	25	486	25	497	25	488	25	505	25	504	25	438
974	868	621	877	70	862	65	907	64	898	60	911	20	956	15	957	5	923
974	395	621	498	70	450	65	462	65	430	60	445	20	376	15	412	5	371
51	927	28	924	-	-	-	-	-	-	-	-	-	-	-	-	-	-
51	433	28	428	-	-	-	-	-	-	-	-	-	-	-	-	-	-
251	475	251	538	15	597	15	664	15	692	15	709	15	728	15	667	-	-
250	281	252	378	15	448	15	496	15	486	15	486	15	481	15	454	-	-
20	946	13	970	5	996	5	971	5	874	5	1,047	-	-	5	839	-	-
20	434	13	478	5	474	5	445	5	431	5	352	-	-	5	388	-	-
5,861	832	5,165	850	531	817	455	872	469	856	445	864	380	876	310	863	204	876
5,926	394	5,172	452	555	458	455	455	449	448	440	433	380	401	310	397	205	380
7,065	222	2,925	293	430	351	415	392	-	-	364	423	-	-	230	469	160	471
7,042	183	2,918	273	425	398	410	472	-	-	365	526	-	-	230	605	160	621
1,399	116	1,387	197	355	287	325	376	-	-	300	418	-	-	164	447	100	413

of the Weston Aqueduct, 1901 to 1903, Inclusive.

4,346	664	2,266	718	490	745	275	757	-	-	183	750	93	741	39	832	14	836
4,169	284	3,141	401	523	470	291	446	-	-	191	402	90	405	58	398	15	399
431	659	228	707	98	762	82	764	-	-	66	759	25	808	12	835	-	-
405	323	268	402	102	482	89	476	-	-	91	449	23	433	15	436	-	-
130	719	104	792	73	780	85	830	-	-	65	822	34	830	29	848	14	880
127	269	103	398	67	410	78	397	-	-	61	350	24	449	38	340	15	334
210	639	169	730	64	744	49	765	-	-	48	769	20	827	10	971	10	952
208	314	166	455	68	491	49	490	-	-	50	418	20	433	10	434	10	426
5,117	664	2,767	721	725	750	491	772	-	-	362	767	172	778	90	853	38	883
4,909	288	3,678	403	760	468	507	448	-	-	393	418	157	419	121	388	40	381
4,474	164	2,569	253	220	320	159	355	-	-	186	350	92	380	63	373	24	405
4,415	128	2,586	242	217	335	168	383	-	-	146	355	99	349	55	335	20	333
833	205	409	269	63	312	52	356	-	-	32	394	25	402	15	404	-	-
833	174	431	246	69	345	51	395	-	-	30	467	20	501	15	541	-	-
5,307	170	2,978	255	283	318	211	355	-	-	218	357	117	378	78	379	24	405
5,248	136	3,017	242	286	338	219	386	-	-	176	374	119	374	70	379	20	333



APPENDIX NO. 3.

TABLE NO. 1. — Monthly Rainfall in Inches at Various Places on the Metropolitan Water Works, in 1905.

PLACE.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Totals.
Wachusett Watershed.													
{ Princeton, . . . . .	6.04	1.73	4.14	2.54	1.01	4.44	6.18	3.37	6.35	1.80	2.45	3.91	43.97
{ Jefferson, . . . . .	5.93	1.73	4.27	2.39	0.82	5.74	3.83	3.16	6.64	1.93	2.87	4.09	43.40
{ Sterling, . . . . .	6.43	1.65	3.74	2.62	0.81	4.17	5.49	2.75	6.78	1.63	2.22	3.40	41.09
{ Boylston, . . . . .	5.98	1.78	3.64	2.83	0.66	5.18	6.07	3.09	7.84	1.90	2.51	3.77	45.25
{ Sudbury Dam, . . . . .	5.20	2.58	3.27	2.80	1.29	4.87	6.31	2.63	6.08	1.46	1.93	3.85	42.27
{ Framingham, . . . . .	5.30	2.12	3.21	2.66	1.23	5.03	5.21	2.54	7.16	1.41	1.94	4.02	41.83
{ Ashland Dam, . . . . .	5.28	2.00	3.10	2.48	1.46	4.46	4.96	2.70	6.97	1.52	2.06	3.94	40.98
{ Cordaville, . . . . .	5.27	2.08	3.01	2.95	1.28	5.64	5.38	2.94	7.31	1.79	2.33	4.24	44.22
Lake Cochituate, . . . . .	5.40	2.00	3.28	2.87	1.57	5.46	3.24	2.89	7.00	1.35	2.07	4.07	41.20
Chestnut Hill Reservoir, . . . . .	5.49	2.27	3.34	3.08	1.65	5.38	1.92	3.47	5.93	1.53	2.51	4.27	40.84
Spot Pond, . . . . .	5.61	1.94	3.28	2.54	1.39	5.71	1.01	3.66	7.61	1.41	2.63	3.96	40.75
Average of all, . . . . .	5.63	1.99	3.48	2.70	1.20	5.10	4.51	3.02	6.88	1.61	2.32	3.96	42.40
Average, Wachusett watershed, . . . . .	6.10	1.72	3.95	2.60	0.83	4.88	5.39	3.09	6.90	1.81	2.52	3.79	43.58
Average, Sudbury watershed, . . . . .	5.26	2.20	3.15	2.72	1.31	5.00	5.47	2.70	6.88	1.54	2.07	4.01	42.31

TABLE NO. 2. — *Rainfall in Inches at Jefferson, Mass., in 1905.*

DAY OF MONTH.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1, . . . . .	-	-	-	-	-	-	-	0.05	-	-	-	-
2, . . . . .	1	-	-	-	-	0.25	0.08	0.03	1	-	-	1
3, . . . . .	1	-	-	-	-	-	-	-	1	-	1	1.30
4, . . . . .	1.60 <sup>3</sup>	-	-	1	-	-	-	-	5.38	-	0.65	-
5, . . . . .	-	-	-	1	-	-	-	-	-	-	-	-
6, . . . . .	1	0.80 <sup>3</sup>	-	1.21	-	0.57	-	0.13	0.14	-	0.50	-
7, . . . . .	1.90 <sup>3</sup>	-	1	-	-	1	-	-	-	-	-	-
8, . . . . .	-	-	1	-	-	0.48	-	-	-	-	-	-
9, . . . . .	-	1	0.65 <sup>3</sup>	-	0.14	-	0.35	0.38	-	-	-	1
10, . . . . .	-	0.40 <sup>3</sup>	0.42	1	-	-	1.30	-	-	-	-	0.95 <sup>2</sup>
11, . . . . .	1	-	-	0.75	-	-	-	0.46	1	1	-	-
12, . . . . .	0.65 <sup>3</sup>	1	-	-	1	0.73	-	0.08	0.67	0.76	-	-
13, . . . . .	-	0.47 <sup>3</sup>	-	-	0.14	0.81	0.07	-	-	-	-	-
14, . . . . .	-	-	-	-	0.07	-	-	-	-	-	-	-
15, . . . . .	-	0.02 <sup>2</sup>	-	-	1	-	-	1	-	-	0.26	-
16, . . . . .	-	-	-	-	1	-	-	1.01	-	-	-	-
17, . . . . .	-	-	-	-	1	-	0.47	-	-	-	-	-
18, . . . . .	-	-	-	-	0.32	-	-	-	1	-	-	-
19, . . . . .	-	-	1	-	-	1	0.08	-	1	1	-	-
20, . . . . .	-	0.04 <sup>2</sup>	1	-	-	1	-	-	0.45	1.13	-	-
21, . . . . .	1	-	1	0.43	-	1	-	-	-	-	-	1.14
22, . . . . .	0.32 <sup>2</sup>	-	1.60 <sup>3</sup>	-	-	2.61	-	-	-	-	-	-
23, . . . . .	-	-	-	-	-	-	-	-	-	-	-	0.14
24, . . . . .	1	-	1	-	-	-	-	-	-	0.04	-	-
25, . . . . .	1	-	1.25	-	-	-	-	0.55	-	-	-	-
26, . . . . .	1.40 <sup>2</sup>	-	-	-	-	0.29	-	-	-	-	-	-
27, . . . . .	-	-	0.23	-	0.09	-	-	0.06	-	-	-	-
28, . . . . .	0.06 <sup>2</sup>	-	-	-	-	-	-	-	-	-	1	-
29, . . . . .	-	-	-	-	-	-	1	-	-	-	1.46	0.56
30, . . . . .	-	-	0.12	-	0.06	-	1	0.41	-	-	-	-
31, . . . . .	-	-	-	-	-	-	1.48	-	-	-	-	-
Total, . . . .	5.93	1.73	4.27	2.39	0.82	5.74	3.83	3.16	6.64	1.93	2.87	4.09

Total for the year, 43.40 inches.

<sup>1</sup> Rainfall included in that of following day.<sup>2</sup> Snow.<sup>3</sup> Rain and snow.

TABLE NO. 3. — *Rainfall in Inches at Framingham, Mass., in 1905.*

DAY OF MONTH.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1, . . . . .	-	-	-	-	-	-	-	0.02	0.18	-	-	-
2, . . . . .	1	-	-	-	-	-	0.20	-	1	1	-	1
3, . . . . .	1	-	-	-	-	-	-	0.05	1	0.08	1	1
4, . . . . .	1.58 <sup>3</sup>	-	0.02 <sup>2</sup>	1	-	-	-	-	6.28	-	0.56	1.18 <sup>3</sup>
5, . . . . .	-	1	-	1	0.03	-	-	-	-	-	-	-
6, . . . . .	1	0.97 <sup>3</sup>	-	1.31	0.04	0.46	-	-	0.03	-	0.33	-
7, . . . . .	1.91 <sup>3</sup>	0.02 <sup>2</sup>	1	-	-	1	-	-	-	-	-	-
8, . . . . .	-	-	0.76	-	-	0.58	-	-	-	-	-	-
9, . . . . .	-	1	1	-	0.04	-	0.06	0.08	-	-	-	1
10, . . . . .	-	0.46 <sup>3</sup>	0.39	-	-	-	0.65	0.08	-	-	-	0.72 <sup>2</sup>
11, . . . . .	1	-	-	0.75	-	0.07	0.04	-	1	1	-	-
12, . . . . .	0.58	0.61 <sup>3</sup>	-	-	0.08	1.04	-	0.22	0.39	0.37	-	-
13, . . . . .	-	0.01 <sup>2</sup>	-	-	-	-	0.02	-	-	-	-	-
14, . . . . .	-	-	-	-	0.16	-	0.49	-	-	-	-	-
15, . . . . .	-	-	-	0.02	1	-	-	1	-	-	0.07	-
16, . . . . .	-	-	-	-	0.21	-	-	0.85	0.02	-	-	-
17, . . . . .	-	-	-	-	0.15	-	0.23	-	-	-	-	-
18, . . . . .	-	-	-	-	0.23	-	-	-	1	0.07	-	-
19, . . . . .	-	-	1	-	-	1	0.62	-	1	1	-	-
20, . . . . .	-	0.05 <sup>2</sup>	0.25	1	-	0.63	-	0.02	0.26	0.87	-	-
21, . . . . .	1	-	1	0.56	-	0.76	-	-	-	-	-	1.04
22, . . . . .	0.24 <sup>2</sup>	-	0.75 <sup>2</sup>	-	-	0.83	-	0.27	-	-	-	-
23, . . . . .	-	-	-	-	-	-	-	-	-	-	-	0.15
24, . . . . .	1	-	1	-	-	-	-	-	-	0.02	0.01	-
25, . . . . .	0.98 <sup>2</sup>	-	0.98	-	-	-	-	0.35	-	-	-	-
26, . . . . .	-	-	1	-	-	1	-	-	-	-	-	-
27, . . . . .	-	-	0.03	-	0.16	0.66	-	0.16	-	-	-	-
28, . . . . .	0.01 <sup>2</sup>	-	0.01	-	-	-	-	1	-	-	1	1
29, . . . . .	-	-	-	0.02	-	-	1	0.11	-	-	0.97	0.92
30, . . . . .	-	-	0.02	-	0.13	-	1	0.28	-	-	-	-
31, . . . . .	-	-	-	-	-	-	2.90	0.05	-	-	-	0.01 <sup>2</sup>
Total, . . . . .	5.30	2.12	3.21	2.66	1.23	5.03	5.21	2.54	7.16	1.41	1.94	4.02

Total for the year, 41.83 inches.

<sup>1</sup> Rainfall included in that of following day.<sup>2</sup> Snow.<sup>3</sup> Rain and snow.



TABLE NO. 4.—*Rainfall in Inches at Chestnut Hill Reservoir in 1905.*

DATE.	Amount.	Duration.	DATE.	Amount	Duration.
Jan. 2, . . .	1.47 <sup>1</sup>	10.15 A.M. to	June 2, . . .	0.02	3.50 P.M. to 6.10 P.M.
Jan. 4, . . .		2.30 P.M.	June 6, . . .	0.51	1.30 A.M. to 5.15 P.M.
Jan. 6, . . .	1.88 <sup>1</sup>	4.55 A.M. to	June 7, . . .	0.68	8.30 P.M. to
Jan. 7, . . .		8.10 A.M.	June 8, . . .		1.00 P.M.
Jan. 11, . . .	0.60	11.20 P.M. to	June 11, . . .	1.60	10.05 P.M. to
Jan. 12, . . .		7.00 A.M.	June 13, . . .		2.45 A.M.
Jan. 21, . . .	0.15 <sup>2</sup>	7.30 P.M. to	June 19, . . .	2.00	4.30 A.M. to
Jan. 22, . . .		2.20 P.M.	June 22, . . .		5.45 A.M.
Jan. 24, . . .	1.32 <sup>2</sup>	6.30 P.M. to	June 26, . . .	0.41	2.15 A.M. to
Jan. 25, . . .		11.35 P.M.	June 27, . . .		7.20 P.M.
Jan. 28, . . .	0.07 <sup>2</sup>	1.30 P.M. to 5.00 P.M.	June 28, . . .	0.14	11.30 A.M. to 3.00 P.M.
June 29, . . .			June 29, . . .	0.02	1.15 P.M. to 1.30 P.M.
Total, . . .	5.49		Total, . . .	5.38	
Feb. 6, . . .	1.05 <sup>2</sup>	6.00 A.M. to	July 2, . . .	0.31	5.15 A.M. to
Feb. 7, . . .		4.00 P.M.	July 3, . . .		3.00 A.M.
Feb. 8, . . .	0.60 <sup>2</sup>	8.00 P.M. to	July 10, . . .	0.04	4.20 A.M. to 6.40 A.M.
Feb. 10, . . .		3.10 A.M.	July 14, . . .	0.82 <sup>3</sup>	6.05 P.M. to 11.55 P.M.
Feb. 12, . . .	0.56 <sup>2</sup>	4.30 P.M. to	July 16, . . .	0.06	10.05 P.M. to 11.25 P.M.
Feb. 13, . . .		4.45 P.M.	July 17, . . .	0.02	5.45 A.M. to 8.10 A.M.
Feb. 20, . . .	0.06 <sup>2</sup>	11.00 A.M. to 6.00 P.M.	July 19, . . .	0.04	1.35 P.M. to 5.00 P.M.
Total, . . .	2.27		July 29, . . .	0.63	4.45 P.M. to
			Aug. 1, . . .		7.00 A.M.
			Total, . . .	1.92	
Mar. 4, . . .	0.05 <sup>2</sup>	5.05 A.M. to 3.30 P.M.	Aug. 1, . . .	0.02	7.00 A.M. to 4.20 P.M.
Mar. 7, . . .	0.91	10.00 P.M. to	Aug. 2, . . .	0.07	3.40 P.M. to 4.15 P.M.
Mar. 9, . . .		12.25 P.M.	Aug. 3, . . .	0.09	4.00 A.M. to 6.30 A.M.
Mar. 10, . . .	0.40	8.00 P.M. to 11.25 P.M.	Aug. 9, . . .	0.15	1.15 P.M. to 8.00 P.M.
Mar. 19, . . .	0.24	6.05 A.M. to 10.30 P.M.	Aug. 12, . . .	1.06	11.40 A.M. to 4.30 P.M.
Mar. 20, . . .	0.03	1.20 A.M. to 7.30 A.M.	Aug. 15, . . .	0.62	5.45 A.M. to 11.00 A.M.
Mar. 21, . . .	1.04 <sup>3</sup>	11.45 A.M. to	Aug. 16, . . .	0.18	3.30 P.M. to 9.10 P.M.
Mar. 22, . . .		6.45 A.M.	Aug. 22, . . .	0.22 <sup>3</sup>	6.05 P.M. to 6.45 P.M.
Mar. 25, . . .	0.53	12.10 A.M. to	Aug. 24, . . .	0.29	11.00 P.M. to
Mar. 26, . . .		2.20 A.M.	Aug. 25, . . .		3.20 P.M.
Mar. 28, . . .	0.04	10.00 P.M. to 12.00 P.M.	Aug. 27, . . .	0.19	8.20 A.M. to 9.30 A.M.
Mar. 30, . . .	0.10	9.00 P.M. to 10.15 P.M.	Aug. 29, . . .	0.11	2.00 A.M. to 5.45 A.M.
Total, . . .	3.34		Aug. 30, . . .	0.44 <sup>3</sup>	9.00 P.M. to 11.05 P.M.
			Aug. 31, . . .	0.03	4.35 A.M. to 10.20 A.M.
			Total, . . .	3.47	
Apr. 4, . . .	1.74	10.40 P.M. to	Sept. 2, . . .	5.24	9.38 P.M. to
Apr. 6, . . .		11.30 A.M.	Sept. 4, . . .		2.35 P.M.
Apr. 11, . . .	0.82	4.50 A.M. to	Sept. 6, . . .	0.20 <sup>3</sup>	5.55 P.M. to 6.30 P.M.
Apr. 12, . . .		1.30 A.M.	Sept. 11, . . .	0.24	3.30 P.M. to
Apr. 20, . . .	0.50	6.10 P.M. to	Sept. 13, . . .		1.30 A.M.
Apr. 22, . . .		3.15 A.M.	Sept. 17, . . .	0.25	11.20 P.M. to
Apr. 29, . . .	0.02	4.30 P.M. to 8.00 P.M.	Sept. 19, . . .		12.45 A.M.
Total, . . .	3.08		Total, . . .	5.93	
May 6, . . .	0.04	2.05 A.M. to 4.00 A.M.	Oct. 3, . . .	0.07	3.30 A.M. to 7.00 A.M.
May 7, . . .	0.04 <sup>3</sup>	1.05 A.M. to 4.15 A.M.	Oct. 11, . . .	0.30	9.40 P.M. to
May 9, . . .	0.07	5.10 A.M. to 8.00 A.M.	Oct. 12, . . .		5.50 A.M.
May 12, . . .	0.06	2.55 A.M. to	Oct. 19, . . .	1.14	10.20 P.M. to
May 13, . . .		1.15 A.M.	Oct. 22, . . .		8.30 A.M.
May 14, . . .	0.30	1.10 P.M. to	Oct. 24, . . .	0.02	9.30 P.M. to
May 16, . . .		12.30 A.M.	Oct. 25, . . .		1.30 A.M.
May 18, . . .	0.37 <sup>3</sup>	1.00 A.M. to 9.15 P.M.	Total, . . .	1.53	
May 19, . . .	0.62	5.45 A.M. to 8.15 A.M.			
May 30, . . .	0.15	1.05 A.M. to 2.10 A.M.			
Total, . . .	1.65				

<sup>1</sup> Rain and snow.<sup>2</sup> Snow.<sup>3</sup> Thunder storm.

TABLE NO. 4. — *Rainfall in Inches at Chestnut Hill Reservoir in 1905 —*  
Concluded.

DATE.	Amount.	Duration	DATE.	Amount.	Duration.
Nov. 3, . . .	{ 0.81	12.05 A.M. to	Dec. 2, . . .	{ 1.23	9.30 P.M. to
Nov. 4, . . .		7.00 A.M.	Dec. 3, . . .		3.15 P.M.
Nov. 6, . . .	{ 0.33	9.00 A.M. to	Dec. 9, . . .	{ 1.12 <sup>2</sup>	8.45 P.M. to
Nov. 7, . . .		4.00 A.M.	Dec. 10, . . .		12.25 A.M.
Nov. 15, . . .	{ 0.08	7.00 P.M. to	Dec. 21, . . .	1.05	4.30 A.M. to 2.30 P.M.
Nov. 16, . . .		1.45 A.M.	Dec. 23, . . .	0.19	7.20 A.M. to 6.30 P.M.
Nov. 24, . . .	{ 0.03	9.50 P.M. to	Dec. 29, . . .	0.65	3.55 A.M. to 1.20 P.M.
Nov. 25, . . .		2.00 A.M.	Jan. 1, '06, . . .	0.03 <sup>2</sup>	2.50 A.M. to 5.25 A.M.
Nov. 28, . . .	{ 1.26	5.00 P.M. to	Total, . . .	4.27	
Nov. 29, . . .		9.45 P.M.			
Total, . . .	2.51				

Total for the year, 40.84 inches.

<sup>1</sup> Rain and snow.

<sup>2</sup> Snow.

<sup>3</sup> Thunder storm.

TABLE NO. 5. — *Rainfall in Inches on the Wachusett Watershed, 1897 to 1905.*

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Totals.
1897, .	3.46	2.86	4.01	2.32	5.06	5.11	8.65	3.47	1.93	0.94	7.62	6.41	51.84
1898, .	6.65	3.30	2.27	4.43	3.38	3.11	3.01	10.61	3.15	7.21	6.81	3.99	57.92
1899, .	2.93	5.12	6.75	1.94	1.33	5.51	3.32	3.20	4.11	2.72	1.94	2.03	41.40
1900, .	4.56	8.69	6.19	2.76	4.34	3.59	3.20	3.18	3.46	2.90	6.44	3.15	52.46
1901, .	1.75	1.13	5.82	9.64	7.02	1.51	5.66	4.58	3.10	3.70	2.43	9.36	55.70
1902, .	2.72	4.91	5.27	4.36	2.24	2.51	3.37	3.95	4.26	6.36	0.93	7.20	48.58
1903, .	2.85	4.42	6.58	3.10	1.24	10.37	3.43	3.88	2.93	4.43	2.36	3.99	49.58
1904, .	4.02	2.66	3.40	7.45	2.99	3.44	3.34	3.68	5.30	1.78	1.62	2.88	43.06
1905, .	6.10	1.72	3.95	2.60	0.83	4.88	5.39	3.09	6.90	1.81	2.52	3.79	43.58
Total,	35.04	34.81	44.24	38.60	28.43	40.03	40.37	39.64	35.14	31.85	32.67	42.80	444.12
Average, .	3.89	3.87	4.92	4.29	3.16	4.45	4.54	4.40	3.90	3.54	3.63	4.76	49.35

NOTE. — The figures tabulated are means of observations at four places, as follows: January, 1897, to December, 1900, Princeton, Jefferson, Sterling and South Clinton; January, 1901, to December, 1905, Princeton, Jefferson, Sterling and Boylston.



TABLE No. 6. — *Rainfall in Inches on the Sudbury Watershed,<sup>1</sup> 1875 to 1905.*

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Totals.
1875, . . . . .	2.42	3.15	3.74	3.23	3.56	6.24	3.57	5.53	3.43	4.85	4.83	0.94	45.49
1876, . . . . .	1.83	4.21	7.43	4.20	2.76	2.04	9.13	1.72	4.62	2.24	5.76	3.62	49.56
1877, . . . . .	3.22	3.74	8.36	3.43	3.70	2.43	2.95	3.68	0.32	8.52	5.80	0.87	44.02
1878, . . . . .	5.63	5.97	4.69	5.79	0.96	3.88	2.97	6.94	1.29	6.42	7.02	6.37	57.93
1879, . . . . .	2.48	3.66	5.14	4.72	1.58	3.79	3.93	6.51	1.88	0.81	2.68	4.34	41.42
1880, . . . . .	3.57	3.98	3.31	3.11	1.84	2.14	6.27	4.01	1.60	3.74	1.78	2.83	38.18
1881, . . . . .	5.56	4.65	5.73	2.00	3.51	5.39	2.35	1.36	2.62	2.95	4.09	3.96	44.17
1882, . . . . .	5.95	4.55	2.65	1.82	6.07	1.66	1.77	1.67	8.74	2.07	1.15	2.20	39.40
1883, . . . . .	2.81	3.87	1.78	1.84	4.19	2.40	2.68	0.73	1.52	3.60	1.81	3.55	32.78
1884, . . . . .	5.09	6.54	4.72	4.41	3.47	3.44	3.67	4.65	0.85	2.48	2.65	5.17	47.14
1885, . . . . .	4.71	3.87	1.07	3.60	3.48	2.87	1.43	7.18	1.43	5.09	6.09	2.72	43.54
1886, . . . . .	6.36	6.28	3.61	2.22	3.00	1.47	3.27	4.10	2.90	3.24	4.64	4.97	46.06
1887, . . . . .	5.20	4.78	4.90	4.27	1.16	2.65	3.76	5.28	1.32	2.83	2.67	3.89	42.70
1888, . . . . .	4.15	3.68	6.02	2.43	4.82	2.54	1.41	6.22	8.59	4.99	7.22	5.40	57.47
1889, . . . . .	5.37	1.65	2.37	3.41	2.95	2.80	8.94	4.18	4.60	4.25	6.29	3.14	49.95
1890, . . . . .	2.53	3.51	7.73	2.64	5.21	2.03	2.46	3.87	6.00	10.51	1.20	5.31	53.00
1891, . . . . .	7.02	5.23	6.48	3.91	2.01	3.77	3.39	4.73	2.38	3.83	3.09	3.63	49.52
1892, . . . . .	5.85	3.14	4.06	0.83	5.58	2.76	4.23	4.44	2.84	1.17	5.80	1.13	41.83
1893, . . . . .	2.92	8.20	3.67	3.60	6.61	2.58	2.57	5.41	1.74	4.07	2.20	4.86	48.23
1894, . . . . .	4.09	3.91	1.43	3.42	4.24	1.15	3.26	2.03	2.63	5.34	3.43	4.81	39.74
1895, . . . . .	4.06	1.39	2.98	5.25	2.02	2.77	5.04	4.15	2.30	10.68	6.63	3.35	50.62
1896, . . . . .	2.39	7.18	5.24	1.57	2.57	3.22	2.51	2.40	7.72	3.76	3.02	2.12	43.70
1897, . . . . .	4.00	2.91	3.66	2.82	4.37	4.46	5.44	3.51	2.94	0.47	6.40	5.21	46.19
1898, . . . . .	6.83	4.49	2.40	4.66	3.22	2.48	4.09	8.17	2.62	6.71	6.93	3.28	55.88
1899, . . . . .	4.18	4.91	7.01	1.90	1.45	2.51	3.22	1.43	3.95	2.69	2.18	1.78	37.21
1900, . . . . .	4.96	9.14	6.35	2.58	4.32	1.99	2.42	2.26	3.36	3.83	5.70	2.74	60.65
1901, . . . . .	1.82	1.52	6.57	8.60	7.23	1.38	5.71	4.57	3.30	2.82	2.90	9.69	56.11
1902, . . . . .	2.52	6.18	5.34	4.13	1.86	2.89	2.94	3.40	4.54	4.44	1.45	6.38	46.07
1903, . . . . .	3.80	3.95	6.63	2.99	0.93	9.25	2.77	3.67	1.75	4.72	1.56	3.14	45.16
1904, . . . . .	4.87	3.00	2.72	8.87	2.65	2.80	1.96	3.86	1.73	1.64	1.73	2.92	42.82
1905, . . . . .	5.26	2.20	3.15	2.72	1.31	5.00	5.47	2.70	6.88	1.54	2.07	4.01	42.31
Total, . . . . .	131.45	132.34	140.94	110.97	101.63	97.58	115.58	124.36	106.46	128.30	120.77	118.47	1,428.85
Average, . . . . .	4.24	4.27	4.55	3.58	3.28	3.15	3.73	4.01	3.43	4.14	3.89	3.82	46.09

<sup>1</sup> Means of observations at several places, as follows: January, 1875, to April, 1876, Lake Cochituate; April to June, 1876, Lake Cochituate, Westborough and Hopkinton; June to December, 1876, Lake Cochituate, Southborough, Marlborough, Westborough and Hopkinton; December, 1876, to January, 1883, Framingham, Southborough, Marlborough, Westborough and Hopkinton; January, 1883, to January, 1884, Framingham and Southborough; January, 1884, to January, 1890, Framingham and Westborough; January, 1890, to May, 1898, Framingham and Ashland Dam; June, 1898, to December, 1905, Framingham, Ashland Dam, Cordaville and Sudbury Dam.

TABLE NO. 7. — *Yield of the Wachusett Watershed in Gallons per Day per Square Mile<sup>1</sup> from 1897 to 1905.*

MONTH.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	Mean for 9 Years 1897-1905.
January, . . . . .	796,000	1,563,000	2,092,000	796,000	519,000	1,676,000	1,265,000	659,000	1,266,000	1,181,000
February, . . . . .	931,000	1,635,000	1,090,000	4,054,000	356,000	1,401,000	2,133,000	927,000	452,000	1,440,000
March, . . . . .	2,760,000	3,088,000	2,776,000	3,722,000	2,718,000	3,992,000	3,423,000	3,008,000	3,004,000	3,165,000
April, . . . . .	1,632,000	2,027,000	3,376,000	1,580,000	4,986,000	2,159,000	2,238,000	2,984,000	1,617,000	2,511,000
May, . . . . .	1,163,000	1,390,000	862,000	1,382,000	2,729,000	1,031,000	569,000	1,498,000	445,000	1,230,000
June, . . . . .	1,181,000	828,000	561,000	578,000	985,000	410,000	2,131,000	762,000	542,000	887,000
July, . . . . .	1,442,000	333,000	354,000	217,000	477,000	292,000	624,000	497,000	365,000	511,000
August, . . . . .	896,000	1,325,000	236,000	197,000	512,000	297,000	474,000	355,000	321,000	512,000
September, . . . . .	380,000	676,000	250,000	127,000	320,000	241,000	375,000	494,000	1,228,000	454,000
October, . . . . .	243,000	1,509,000	245,000	282,000	647,000	950,000	689,000	347,000	367,000	587,000
November, . . . . .	1,282,000	2,170,000	430,000	875,000	517,000	635,000	634,000	343,000	442,000	814,000
December, . . . . .	2,275,000	2,061,000	359,000	1,570,000	3,234,000	1,848,000	954,000	440,000	1,018,000	1,529,000
Average for year, . . . . .	1,253,000	1,551,000	1,051,000	1,264,000	1,507,000	1,248,000	1,285,000	1,025,000	926,000	1,234,000
Average for driest 6 months, . . . . .	886,000	1,013,000	312,000	377,000	576,000	471,000	626,000	413,000	541,000	626,000

<sup>1</sup> The area of the watershed used in making up these records included water surfaces amounting to 2.2 per cent. of the whole area from 1897 to 1902, inclusive, to 2.4 per cent. in 1903, to 3.6 per cent. in 1904, and to 4.1 per cent. in 1905.

TABLE NO. 8. — *Yield of the Sudbury Watershed in Gallons per Day per Square Mile<sup>1</sup> from 1875 to 1905.*

MONTH.		1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	1883.	1884.
January, . . . . .	.	103,000	643,000	658,000	1,810,000	700,000	1,120,000	415,000	1,241,000	335,000	995,000
February, . . . . .	.	1,496,000	1,368,000	949,000	2,465,000	1,711,000	1,787,000	1,546,000	2,403,000	1,033,000	2,842,000
March, . . . . .	.	1,604,000	4,435,000	4,814,000	3,507,000	2,330,000	1,374,000	4,004,000	2,839,000	1,611,000	3,785,000
April, . . . . .	.	3,049,000	3,292,000	2,394,000	1,626,000	3,116,000	1,169,000	1,546,000	867,000	1,350,000	2,553,000
May, . . . . .	.	1,188,000	1,138,000	1,391,000	1,394,000	1,114,000	514,000	965,000	1,292,000	937,000	1,030,000
June, . . . . .	.	870,000	222,000	597,000	506,000	413,000	175,000	1,338,000	529,000	300,000	416,000
July, . . . . .	.	321,000	183,000	202,000	128,000	157,000	176,000	276,000	86,000	115,000	224,000
August, . . . . .	.	396,000	405,000	121,000	476,000	395,000	119,000	148,000	55,000	79,000	257,000
September, . . . . .	.	207,000	184,000	60,000	161,000	141,000	80,000	197,000	307,000	91,000	44,000
October, . . . . .	.	646,000	234,000	631,000	516,000	71,000	102,000	186,000	299,000	186,000	83,000
November, . . . . .	.	1,302,000	1,088,000	1,418,000	1,693,000	206,000	205,000	395,000	209,000	205,000	175,000
December, . . . . .	.	584,000	453,000	1,290,000	3,177,000	463,000	175,000	775,000	315,000	194,000	925,000
Average for year, . . . . .	.	972,000	1,135,000	1,214,000	1,452,000	894,000	578,000	979,000	862,000	533,000	1,129,000
Average for driest 6 months, . . . . .	.	574,000	384,000	502,000	532,000	230,000	143,000	330,000	211,000	145,000	200,000

<sup>1</sup> The area of the Sudbury watershed used in making up these records included water surfaces amounting to 1.9 per cent. of the whole area from 1875 to 1878 inclusive, and subsequently increased by the construction of storage reservoirs to 3.0 per cent. in 1879, 3.4 per cent. in 1885, 3.9 per cent. in 1894 and 6.5 per cent. in 1898. The watershed also contains extensive areas of swampy land, which, though covered with water at times, are not included in the above percentages of water surfaces.



TABLE NO. 8. — *Yield of the Sudbury Watershed in Gallons per Day per Square Mile<sup>1</sup> from 1875 to 1905* — Continued.

MONTH.	1885.	1886.	1887.	1888.	1889.	1890.	1891.	1892.	1893.	1894.
January, . . . . .	1,235,000	1,461,000	2,589,000	1,053,000	2,782,000	1,254,000	3,018,000	1,870,000	434,000	683,000
February, . . . . .	1,354,000	4,801,000	2,829,000	1,950,000	1,196,000	1,529,000	3,486,000	943,000	1,542,000	991,000
March, . . . . .	1,572,000	2,059,000	2,868,000	3,238,000	1,338,000	3,643,000	4,453,000	1,955,000	3,245,000	2,238,000
April, . . . . .	1,815,000	1,947,000	2,620,000	2,645,000	1,410,000	1,875,000	2,397,000	871,000	2,125,000	1,640,000
May, . . . . .	1,335,000	720,000	1,009,000	1,632,000	880,000	1,366,000	583,000	1,259,000	2,883,000	840,000
June, . . . . .	426,000	203,000	413,000	421,000	653,000	568,000	413,000	428,000	440,000	419,000
July, . . . . .	62,000	116,000	115,000	117,000	634,000	107,000	149,000	214,000	158,000	161,000
August, . . . . .	240,000	94,000	214,000	379,000	1,432,000	132,000	163,000	280,000	181,000	209,000
September, . . . . .	121,000	117,000	111,000	1,155,000	823,000	457,000	203,000	229,000	108,000	150,000
October, . . . . .	336,000	146,000	190,000	1,999,000	1,230,000	2,272,000	210,000	126,000	222,000	374,000
November, . . . . .	1,177,000	673,000	369,000	2,758,000	1,941,000	1,215,000	305,000	697,000	319,000	836,000
December, . . . . .	1,174,000	1,020,000	643,000	3,043,000	2,241,000	996,000	544,000	485,000	796,000	716,000
Average for year, . . . . .	901,000	1,087,000	1,154,000	1,697,000	1,383,000	1,285,000	1,315,000	781,000	1,037,000	770,000
Average for driest 6 months, . . . . .	391,000	223,000	234,000	953,000	944,000	747,000	239,000	327,000	237,000	356,000

<sup>1</sup> The area of the Sudbury watershed used in making up these records included water surfaces amounting to 1.9 per cent. of the whole area from 1875 to 1878 inclusive, and subsequently increased by the construction of storage reservoirs to 3.0 per cent. in 1879, 3.4 per cent. in 1885, 3.9 per cent. in 1894 and 6.5 per cent. in 1898. The watershed also contains extensive areas of swampy land, which, though covered with water at times, are not included in the above percentages of water surfaces.

TABLE NO. 8. — *Yield of the Sudbury Watershed in Gallons per Day per Square Mile<sup>1</sup> from 1875 to 1905*—Concluded.

MONTH.	1895.	1896.	1897.	1898.	1899.	1900.	1901.	1902.	1903.	1904.	1905.	Mean for 31 Years, 1875-1905.
January, . . . . .	1,034,000	1,084,000	845,000	1,638,000	2,288,000	794,000	437,000	1,763,000	1,736,000	477,000	1,410,000	1,223,000
February, . . . . .	541,000	2,676,000	1,067,000	3,022,000	1,381,000	3,800,000	300,000	1,674,000	2,279,000	882,000	330,000	1,812,000
March, . . . . .	2,410,000	3,855,000	2,565,000	2,604,000	4,205,000	3,654,000	2,755,000	4,199,000	3,454,000	2,999,000	2,497,000	2,971,000
April, . . . . .	2,515,000	1,494,000	1,515,000	1,829,000	2,521,000	1,350,000	4,204,000	1,885,000	2,261,000	3,294,000	1,643,000	2,100,000
May, . . . . .	636,000	360,000	915,000	1,246,000	511,000	1,312,000	2,954,000	743,000	351,000	1,745,000	297,000	1,114,000
June, . . . . .	174,000	399,000	962,000	530,000	66,000	316,000	753,000	303,000	1,987,000	419,000	467,000	520,000
July, . . . . .	231,000	95,000	658,000	231,000	15,000	—18,000	306,000	66,000	445,000	62,000	177,000	193,000
August, . . . . .	229,000	57,000	591,000	1,107,000	—35,000	—34,000	424,000	135,000	307,000	170,000	114,000	285,000
September, . . . . .	89,000	388,000	182,000	369,000	94,000	65,000	305,000	178,000	130,000	397,000	1,246,000	271,000
October, . . . . .	1,379,000	592,000	94,000	1,160,000	115,000	186,000	412,000	506,000	492,000	191,000	158,000	495,000
November, . . . . .	2,777,000	655,000	909,000	1,986,000	304,000	663,000	474,000	444,000	363,000	289,000	279,000	849,000
December, . . . . .	1,782,000	657,000	1,584,000	1,799,000	220,000	1,096,000	2,695,000	1,779,000	582,000	269,000	887,000	1,076,000
Average for year, . . . . .	1,152,000	1,019,000	991,000	1,450,000	973,000	1,082,000	1,342,000	1,140,000	1,190,000	931,000	795,000	1,072,000
Average for driest six months, . . . . .	460,000	314,000	564,000	777,000	93,000	194,000	445,000	271,000	388,000	228,000	403,000	434,000

<sup>1</sup> The area of the Sudbury watershed used in making up these records included water surfaces amounting to 1.9 per cent. of the whole area from 1875 to 1878 inclusive, and subsequently increased by the construction of storage reservoirs to 3.0 per cent. in 1879, 3.4 per cent. in 1885, 3.9 per cent. in 1894 and 6.5 per cent. in 1898. The watershed also contains extensive areas of swampy land, which, though covered with water at times, are not included in the above percentages of water surfaces.

TABLE NO. 9. — *Wachusett System. — Statistics of Flow of Water, Storage and Rainfall in 1905.*

[Watershed = 119.00 square miles.]

MONTH.	Quantity of Water discharged through Wachusett Aqueduct (Gallons per Day). <sup>1</sup>	Quantity of Water wasted into River below Dam (Gallons per Day).	STORAGE. <sup>2</sup>		Total Yield of Watershed (Gallons per Day).	Rainfall (Inches).	Rainfall collected (Inches).	Percentage of Rainfall collected.
			Gain (Gallons per Day).	Loss (Gallons per Day).				
January, . . . . .	41,142,000	2,384,000	107,106,000	-	150,632,000	6.10	2.258	37.0
February, . . . . .	118,243,000	1,857,000	-	66,657,000	53,829,000	1.72	0.729	42.3
March, . . . . .	30,110,000	2,871,000	323,974,000	-	357,455,000	3.95	5.358	135.7
April, . . . . .	24,937,000	2,520,000	164,437,000	-	192,470,000	2.60	2.792	107.6
May, . . . . .	125,216,000	2,523,000	-	75,394,000	52,945,000	0.83	0.794	99.2
June, . . . . .	121,750,000	2,320,000	-	60,120,000	64,460,000	4.88	0.935	19.2
July, . . . . .	98,052,000	2,071,000	-	57,165,000	43,458,000	5.39	0.651	12.1
August, . . . . .	74,500,000	2,197,000	-	38,987,000	38,210,000	3.09	0.573	18.5
September, . . . . .	56,447,000	2,440,000	86,730,000	-	146,117,000	6.90	2.119	30.7
October, . . . . .	82,271,000	2,103,000	-	41,110,000	43,632,000	1.81	0.654	36.0
November, . . . . .	67,300,000	1,907,000	-	16,973,000	52,633,000	2.52	0.763	30.4
December, . . . . .	26,716,000	2,471,000	91,729,000	-	121,113,000	3.79	1.816	47.9
Total, . . . . .	-	-	-	-	-	43.58	19.442	-
Average for year, . . . . .	71,896,000	2,309,000	35,536,000	-	110,160,000	-	-	44.6

<sup>1</sup> Including small quantities wasted in cleaning aqueduct.

<sup>2</sup> Aggregate storage in Wachusett Reservoir and in ponds and mill reservoirs.



TABLE NO. 10. — *Sudbury System. — Statistics of Flow of Water, Storage and Rainfall in 1905.*

[Watershed from 1875 to 1878 inclusive = 77,764 square miles; in 1879 and 1880 = 78,238 square miles; and from 1881 to 1905 inclusive = 75.2 square miles.]

MONTH.	Quantity of Water received through Wachuset Aqueduct (Gallons per Day). <sup>1</sup>	Quantity of Water discharged through Sudbury Aqueduct (Gallons per Day). <sup>2</sup>	Quantity of Water discharged through Wachuset Aqueduct (Gallons per Day). <sup>2</sup>	Quantity of Water used by Framingham Water Company (Gallons per Day).	Quantity of Water diverted from Sewers, etc. (Gallons per Day).	Quantity of Water wasted into River below Lowell Dam (Gallons per Day).	STORAGE.		Total Yield of Watershed (Gallons per Day).	Rainfall (Inches).	Rainfall collected (Inches).	Percentage of Rainfall collected.
							Gain (Gallons per Day).	Loss (Gallons per Day).				
January, . . .	41,142,000	101,071,000	22,281,000	606,000	839,000	39,816,000	-	17,406,000	106,065,000	5.26	2.516	47.8
February, . . .	118,243,000	103,675,000	30,571,000	664,000	425,000	18,264,000	-	10,564,000	24,783,000	2.20	0.531	24.2
March, . . .	30,110,000	80,194,000	23,703,000	539,000	1,510,000	53,752,000	53,223,000	-	187,810,000	3.15	4.456	141.5
April, . . .	24,937,000	53,860,000	33,617,000	520,000	2,297,000	50,297,000	7,927,000	-	123,580,000	2.72	2.837	104.2
May, . . .	125,216,000	88,965,000	33,758,000	548,000	1,135,000	6,100,000	17,077,000	-	22,368,000	1.31	0.520	40.4
June, . . .	121,750,000	80,273,000	32,520,000	587,000	777,000	6,423,000	36,303,000	-	35,133,000	5.00	0.806	16.1
July, . . .	98,052,000	78,761,000	33,323,000	594,000	661,000	1,500,000	-	3,445,000	13,342,000	5.47	0.316	5.8
August, . . .	74,500,000	71,048,000	33,148,000	548,000	639,000	1,500,000	-	23,784,000	8,600,000	2.70	0.204	7.6
September, . . .	56,447,000	79,267,000	31,140,000	557,000	1,397,000	21,287,000	16,470,000	-	93,720,000	6.88	2.152	31.3
October, . . .	82,271,000	62,771,000	32,100,000	558,000	719,000	13,119,000	-	15,094,000	11,903,000	1.54	0.282	18.3
November, . . .	67,300,000	61,717,000	32,163,000	543,000	557,000	1,500,000	-	8,213,000	20,967,000	2.07	0.481	23.3
December, . . .	26,490,000	74,126,000	33,474,000	542,000	1,116,000	7,565,000	-	23,597,000	66,735,000	4.01	1.583	39.5
Total, . . .	-	-	-	-	-	-	-	-	-	42.31	16.694	-
Av. for year,	71,877,000	77,867,000	30,972,000	567,000	1,008,000	18,837,000	2,397,000	-	59,775,000	-	-	39.5

<sup>1</sup> Not including quantities of water wasted in cleaning aqueduct, which were not discharged into Sudbury Reservoir.

<sup>2</sup> Including quantities of water wasted from aqueduct.

TABLE No. 11. — *Cochinuate System.* — *Statistics of Flow of Water, Storage and Rainfall in 1905.*

[Watershed of lake = 18.87 square miles.<sup>1</sup>]

MONTH.	Quantity of Water received from External Sources (Gallons per Day). <sup>2</sup>	Quantity of Water discharged through Cochinate Aqueduct (Gallons per Day).	Quantity of Water diverted from Water-shed by Sewers, etc. (Gallons per Day).	Quantity of Water wasted at Outlet (Gallons per Day).	STORAGE.		Total Yield of Water-shed (Gallons per Day).	Rainfall collected (Inches).	Percent- age of Rainfall collected.
					Gain (Gallons per Day).	Loss (Gallons per Day).			
January,	-	-	658,000	-	21,587,000	-	22,245,000	5.40	38.9
February,	-	5,939,000	486,000	375,000	-	1,654,000	5,146,000	2.00	22.0
March,	-	20,261,000	739,000	5,748,000	11,384,000	-	38,132,000	3.28	109.9
April,	-	20,940,000	1,053,000	5,810,000	-	2,630,000	25,173,000	2.87	80.2
May,	1,465,000	2,948,000	519,000	-	4,468,000	-	6,471,000	1.57	39.0
June,	-	3,583,000	400,000	4,297,000	-	4,333,000	7,847,000	5.46	13.2
July,	671,000	12,716,000	406,000	-	-	10,258,000	2,194,000	3.24	6.4
August,	-	25,239,000	284,000	-	-	18,555,000	6,968,000	2.89	22.8
September,	17,347,000	24,750,000	807,000	-	11,880,000	-	20,090,000	7.00	26.3
October,	-	24,726,000	477,000	-	-	16,852,000	8,352,000	1.35	58.5
November,	-	21,770,000	407,000	-	-	11,470,000	10,707,000	2.07	47.3
December,	9,429,000	21,045,000	626,000	-	4,803,000	-	17,045,000	4.07	39.6
Total,	-	-	-	-	-	-	-	41.20	-
Average for year,	2,408,000	15,377,000	572,000	1,348,000	-	636,000	14,253,000	-	38.5

<sup>1</sup> Not including the watershed of Dudley Pond.

<sup>2</sup> From Framingham reservoirs Nos. 1, 2 and 3, and Dudley Pond.

TABLE NO. 12. — *Elevations of Water Surfaces of Reservoirs above Boston City Base at the Beginning of Each Month.*

DATE.	Chestnut Hill Reservoir. Ordinary High Water = 134.00.	Lake Cochituate. High Water = 144.36.	Farm Pond. High Water = 159.25.	Spot Pond. High Water = 163.00.	Weston Reservoir. High Water = 200.00.	FRAMINGHAM RESERVOIR.			Ashland Reservoir. Flash Boards 225.23.	Sudbury Reservoir. Flash Boards 259.97.	Hopkinton Reservoir. Flash Boards 305.00.	Whitehall Reservoir. Ordinary High Water = 337.91.	Wachusett Reservoir.
						No. 1. Flash Boards 169.27.	No. 2. Flash Boards 177.12.	No. 3. Flash Boards 186.50.					
Jan. 1, 1905, .	133.98	139.84	158.14	163.57	194.47	166.65	177.09	184.25	193.87	259.18	273.52	336.74	317.00
Feb. 1, 1905, .	133.29	142.91	158.50	161.65	195.16	167.76	176.09	183.78	203.46	256.90	283.19	336.10	325.77
Mar. 1, 1905, .	134.03	142.71	158.38	159.79	199.98	167.55	174.56	183.48	205.58	257.14	284.80	333.78	321.20
April 1, 1905, .	132.36	144.16	158.63	162.52	200.01	168.01	176.29	183.42	216.30	257.93	296.18	335.39	341.20
May 1, 1905, .	132.44	143.85	158.52	161.91	199.92	168.30	177.27	183.62	222.42	256.29	301.63	336.56	349.33
June 1, 1905, .	133.83	144.39	158.93	163.27	199.67	169.34	177.45	183.75	224.30	256.94	302.66	336.64	346.02
July 1, 1905, .	133.55	144.34	158.77	162.98	199.49	169.32	177.39	183.45	225.35	259.19	303.91	336.98	343.20
Aug. 1, 1905, .	132.16	143.06	158.43	163.17	199.47	169.10	177.10	184.53	222.78	259.32	303.19	336.87	340.49
Sept. 1, 1905, .	131.97	140.46	158.14	162.93	200.01	168.81	176.69	183.76	217.59	259.19	298.18	336.80	338.45
Oct. 1, 1905, .	131.85	142.10	158.54	163.01	199.39	169.57	174.22	184.14	220.63	259.21	302.04	337.44	342.59
Nov. 1, 1905, .	131.98	139.66	158.20	163.01	199.83	169.17	176.18	183.54	217.92	259.16	296.85	337.40	340.67
Dec. 1, 1905, .	133.88	137.90	158.67	162.92	199.92	168.53	175.20	183.24	218.42	259.06	293.16	337.59	339.94
Jan. 1, 1906, .	132.87	138.68	158.77	163.14	199.91	167.87	176.17	182.06	220.91	256.97	295.74	337.27	344.05



TABLE No. 13. — Average Daily Quantity of Water flowing through Aqueducts in 1905, by Months.<sup>1</sup>

MONTH.	Wachusett Aqueduct into Sudbury Reservoir (Gallons).	Weston Aqueduct into Metro- politan District (Gallons).	SUDBURY AQUEDUCT INTO CHESTNUT HILL RESERVOIR.			Cochituate Aqueduct into Chestnut Hill Reservoir (Gallons).
			From Framingham Reservoir No. 3 (Gallons).	From Framingham Reservoirs Nos. 1 and 2 (Gallons).	Total (Gallons).	
January.	41,142,000	19,632,000	91,435,000	9,636,000	101,071,000	-
February,	118,243,000	30,529,000	93,554,000	10,121,000	103,675,000	5,939,000
March,	30,110,000	23,703,000	65,287,000	14,906,000	80,193,000	20,261,000
April,	24,937,000	33,617,000	52,207,000	-	52,207,000	20,940,000
May,	125,216,000	33,758,000	87,500,000	-	87,500,000	2,194,000
June,	121,750,000	32,520,000	68,733,000	11,540,000	80,273,000	35,833,000
July,	98,052,000	33,323,000	63,639,000	15,122,000	78,761,000	12,716,000
August,	74,500,000	33,148,000	43,345,000	27,703,000	71,048,000	25,239,000
September,	56,447,000	31,140,000	58,453,000	3,517,000	61,970,000	24,750,000
October,	82,271,000	32,100,000	52,600,000	10,171,000	62,771,000	24,726,000
November,	67,300,000	32,163,000	40,757,000	20,863,000	61,620,000	21,770,000
December,	26,490,000	33,465,000	46,765,000	18,026,000	64,791,000	21,045,000
Average,	71,877,000	30,742,000	63,539,000	11,845,000	75,384,000	15,313,000

<sup>1</sup> Not including quantities wasted while cleaning and repairing aqueducts, and not including 2,351,000 gallons per day diverted through the Sudbury Aqueduct to Lake Cochituate.

TABLE No. 14. — Statement of Operations of Engines Nos. 1 and 2 at Chestnut Hill High-service Pumping Station for the Year 1905.

Allowed for slip: { Engine No. 1, 11.29 per cent. January to September, inclusive.  
 Engine No. 1, 3.00 per cent. October to December, inclusive.  
 Engine No. 2, 3.81 per cent.

MONTH.	ENGINE NO. 1.		ENGINE NO. 2.		Total Amount pumped (Million Gallons).	Amount of Coal consumed (Pounds).	Amount of Ashes and Clinkers (Pounds).	Per Cent. of Ashes and Clinkers.	Quantity pumped per Pound of Coal, no Deduction for Heating or Lighting (Gallons).	Average Lift (Feet).		Duty in Foot-pounds per 100 Pounds of Coal, no Deduction for Heating or Lighting, corrected for Slip.	Duty in Foot-pounds per 100 Pounds of Coal, on Basis of Plunger Displacement, no Deduction for Heating or Lighting.
	Hrs.	Min.	Total Pumping Time.	Amount pumped, corrected for Slip (Million Gallons).						No. 1.	No. 2.		
January, . . . . .	251	30	30 50	94.64	12.73	107.37	18,398	10.0	583.51	119.75	119.84	58,210,000	64,940,000
February, . . . . .	323	-	114 20	122.93	44.90	167.83	36,630	11.6	531.71	120.78	120.57	53,470,000	58,970,000
March, . . . . .	207	20	10 -	78.08	3.83	81.91	16,618	13.7	675.50	120.41	120.73	67,770,000	76,010,000
April, . . . . .	90	10	- -	34.80	-	34.80	5,980	12.2	712.17	121.08	-	71,830,000	80,860,000
May, . . . . .	197	50	- -	74.07	-	74.07	9,914	11.6	866.51	120.08	-	86,670,000	97,560,000
June, . . . . .	279	30	3 10	104.95	1.06	106.01	14,974	11.3	803.21	119.38	119.75	79,880,000	89,840,000
July, . . . . .	338	40	63 -	127.71	24.94	152.65	24,239	12.2	767.85	120.02	120.45	76,810,000	85,390,000
August, . . . . .	362	25	- -	135.64	-	135.64	19,272	11.7	823.08	120.81	-	82,830,000	93,240,000
September, . . . . .	147	30	84 25	55.68	31.73	87.41	16,104	10.6	573.32	120.99	120.62	57,710,000	63,180,000
October, . . . . .	25	55	293 25	9.15	104.23	113.38	14,946	10.6	805.17	125.04	121.36	81,600,000	84,850,000
November, . . . . .	429	25	70 -	156.58	24.26	180.84	25,899	10.4	723.39	122.53	126.39	74,140,000	76,550,000
December, . . . . .	388	-	- -	139.57	-	139.57	22,954	12.0	729.38	121.11	-	73,580,000	75,870,000
Total and average, . . . . .	3,041	15	669 10	1,133.80	247.68	1,381.48	225,928	11.4	695.80	120.75	121.43	70,060,000	76,310,000

TABLE NO. 15. — Statement of Operations of Engine No. 3 at Chestnut Hill High-service Pumping Station for the Year 1905.

[7.5 per cent. allowed for slip.]

	MONTH.	Total Pumping Time		Amount pumped, corrected for Slip, (Million Gallons).	Amount of Coal consumed (Pounds).	Amount of Ashes and Clinkers (Pounds).	Per Cent. of Ashes and Clinkers.	Quantity pumped per Pound of Coal, no Deduction for Heating or Lighting (Gallons).	Average Lift (Feet).	Duty in Foot-pounds per 100 Pounds of Coal, no Deduction for Heating or Lighting; corrected for Slip.	Duty in Foot-pounds per 100 Pounds of Coal, on Basis of Plunger Displacement, no Deduction for Heating or Lighting.
		Hrs.	Min.								
January,	. . . . .	-	-	-	-	-	-	-	-	-	-
February,	. . . . .	23	30	22.17	22,160	2,832	12.8	1,000.45	128.03	106,700,000	115,290,000
March,	. . . . .	45	40	42.22	36,338	4,244	11.7	1,191.87	129.70	125,530,000	135,640,000
April,	. . . . .	50	55	47.70	42,105	5,189	12.3	1,132.88	129.11	121,840,000	131,650,000
May,	. . . . .	-	-	-	-	-	-	-	-	-	-
June,	. . . . .	24	30	23.08	23,516	2,794	11.9	981.46	128.90	105,380,000	113,860,000
July,	. . . . .	20	15	19.17	19,019	2,278	12.0	1,007.94	127.22	106,820,000	115,420,000
August,	. . . . .	100	25	94.82	83,165	9,661	11.6	1,140.14	127.24	120,850,000	130,580,000
September,	. . . . .	57	55	53.79	50,957	5,374	10.5	1,055.60	129.09	113,510,000	122,650,000
October,	. . . . .	-	-	-	-	-	-	-	-	-	-
November,	. . . . .	191	-	178.87	147,621	14,948	10.1	1,211.68	127.35	128,540,000	138,890,000
December,	. . . . .	-	-	-	-	-	-	-	-	-	-
Total and average,	. . . . .	514	10	481.82	424,881	47,320	11.1	1,134.01	128.01	120,920,000	130,650,000



TABLE NO. 16. — Statement of Operations of Engine No. 4 at Chestnut Hill High-service Pumping Station for the Year 1905.

[3 per cent. allowed for slip.]

MONTH.	Total Pumping Time.	Hrs. Min.	Amount pumped, corrected for Slip (Million Gallons).	Amount of Coal consumed (Pounds).	Amount of Ashes and Clinkers (Pounds).	Per Cent. of Ashes and Clinkers.	Quantity pumped per Pound of Coal, no Deduction for Heating or Lighting (Gallons).	Average Lift (Feet).	Duty in Foot-pounds per 100 Pounds of Coal, no Deduction for Heating or Lighting; corrected for Slip.	Duty in Foot-pounds per 100 Pounds of Coal, on Bunkers of Plunger Displacement, no Deduction for Heating or Lighting.	SUMMARY OF ENGINES NOS. 1, 2, 3 AND 4.		
											Total Amount pumped, corrected for Slip (Million Gallons).	Daily Average Amount pumped (Million Gallons).	Daily Average Amount pumped (Million Gallons).
January, . . . . .	744	-	949.11	737,531	71,794	9.7	1,286.87	129.81	139,150,000	143,430,000	1,056.48	34.080	
February, . . . . .	646	45	833.20	643,929	74,719	11.6	1,293.93	130.85	141,040,000	145,380,000	1,023.20	26.542	
March, . . . . .	698	05	890.70	745,843	96,250	12.9	1,194.22	131.22	130,540,000	134,550,000	1,014.83	22.736	
April, . . . . .	668	50	861.55	716,952	89,306	12.5	1,201.68	130.57	130,700,000	134,720,000	944.05	31.468	
May, . . . . .	744	-	950.72	754,158	87,908	11.7	1,260.64	128.14	134,560,000	138,700,000	1,024.79	33.058	
June, . . . . .	691	55	887.87	690,051	78,958	11.3	1,270.11	127.45	134,840,000	138,990,000	1,016.96	33.899	
July, . . . . .	723	10	926.62	765,961	94,110	12.3	1,209.75	130.13	131,130,000	135,160,000	1,098.44	35.434	
August, . . . . .	642	25	822.60	655,069	76,792	11.7	1,255.74	131.21	137,250,000	141,470,000	1,053.06	33.970	
September, . . . . .	694	20	884.41	705,486	74,248	10.5	1,253.62	131.16	136,970,000	141,180,000	1,025.61	34.187	
October, . . . . .	744	-	949.46	764,641	81,193	10.6	1,241.71	131.34	135,850,000	140,030,000	1,062.84	34.285	
November, . . . . .	525	50	663.06	539,118	58,198	10.8	1,229.90	131.93	135,160,000	139,320,000	1,022.77	34.092	
December, . . . . .	744	-	945.56	777,445	93,552	12.0	1,216.24	131.43	133,160,000	137,260,000	1,035.13	35.004	
Total and average, . . . . .	8,267	20	10,564.86	8,505,184	977,028	11.5	1,242.17	130.39	134,920,000	139,070,000	12,428.16	34.050	

TABLE No. 17.— Statement of Operations of Engines Nos. 5, 6 and 7 at Chestnut Hill Low-service Pumping Station for the Year 1905.

[3 per cent. allowed for slip.]

MONTH.	ENGINE No. 5.		ENGINE No. 6.		ENGINE No. 7.		Total Amount pumped (Million Gallons).	Daily Average Amount pumped (Million Gallons).	Total Amount of Coal consumed (Pounds).	Per Cent. of Ashes and Clinkers.	Quantity pumped per Pound of Coal, no Deduction for Heating or Lighting (Gallons).	AVERAGE LIFT (FEET).			Duty in Foot-pounds per 100 Pounds of Coal, no Deduction for Heating or Lighting; corrected for Slip.	Duty in Foot-pounds per 100 Pounds of Coal, on Basis of Plunger Displacement, no Deduction for Heating or Lighting.
	ENGINE No. 5.		ENGINE No. 6.		ENGINE No. 7.							Engine No. 5.	Engine No. 6.	Engine No. 7.		
	Total Pumping Time.	Amount pumped, corrected for Slip, (Million Gallons).	Total Pumping Time.	Amount pumped, corrected for Slip, (Million Gallons).	Total Pumping Time.	Amount pumped, corrected for Slip, (Million Gallons).										
January, . . .	Hrs. Min. 453 35	536.04	Hrs. Min. 704 05	834.10	Hrs. Min. 570 30	681.62	2,051.76	66.186	770,782	12.5	2,661.92	48.18	44.87	43.74	100,580,000	103,650,000
February, . . .	572 -	633.35	672 -	734.27	451 20	557.75	1,925.37	68.763	726,090	12.2	2,651.70	52.56	50.51	27.66	98,440,000	101,440,000
March, . . .	605 40	698.74	728 40	824.71	508 -	605.13	2,128.58	68.664	855,665	12.8	2,487.63	58.76	56.99	32.37	104,790,000	107,990,000
April, . . .	274 30	319.10	301 35	290.24	597 15	633.95	1,243.29	41.443	515,055	11.1	2,413.90	57.94	47.41	45.05	98,350,000	101,350,000
May, . . .	572 15	694.02	550 10	657.26	194 50	240.65	1,591.93	51.353	635,813	12.2	2,503.77	52.96	53.57	49.83	109,990,000	113,340,000
June, . . .	- -	-	562 30	706.49	558 05	703.30	1,409.79	46.993	542,500	13.8	2,598.69	-	47.26	47.11	102,140,000	105,260,000
July, . . .	558 50	684.86	684 45	840.17	166 35	205.85	1,730.88	55.835	709,596	13.2	2,439.25	55.74	54.20	51.29	110,660,000	114,040,000
August, . . .	152 15	195.84	582 30	736.46	721 -	916.23	1,848.53	59.630	810,724	11.5	2,280.10	55.94	54.49	59.10	108,130,000	111,430,000
September, . . .	19 30	21.01	618 15	772.36	599 15	754.70	1,548.07	51.602	655,245	11.1	2,362.58	45.80	51.96	51.95	102,080,000	105,190,000
October, . . .	721 -	938.86	493 45	638.83	14 45	17.28	1,594.97	51.451	655,760	11.7	2,432.25	52.32	57.07	62.83	110,090,000	113,450,000
November, . . .	516 -	650.52	372 -	456.44	249 45	314.60	1,421.56	47.385	604,005	12.6	2,353.56	49.89	51.86	49.48	98,870,000	101,890,000
December, . . .	256 30	313.87	399 20	471.04	687 45	825.22	1,610.13	51.940	734,023	13.0	2,193.57	53.46	53.00	53.00	97,010,000	99,970,000
Total and average, . .	4,702 05	5,686.21	6,669 35	7,962.37	5,319 05	6,456.28	20,104.86	55.082	8,215,258	12.3	2,447.26	53.44	52.09	46.90	103,570,000	106,730,000

TABLE No. 18.— Statement of Operations of Engines Nos. 8 and 9 at Spot Pond Pumping Station for the Year 1905.

[Engine No. 8, 2.02 per cent. allowed for slip.]

MONTH.	Total Pumping Time.	Amount pumped, corrected for Slip, (Million Gallons).	Amount of Coal consumed (Pounds).	Amount of Ashes and Clinkers (Pounds).	Per Cent. of Ashes and Clinkers.	Quantity pumped per Pound of Coal, no Deduction for Heating or Lighting (Gallons).	Average Lift (Feet).	Duty in Foot-pounds per 100 Pounds of Coal, no Deduction for Heating or Lighting, corrected for Slip.	Duty in Foot-pounds per 100 Pounds of Coal on Basis of Plunger Displacement, no Deduction for Heating or Lighting.	SUMMARY FOR ENGINES Nos. 8 AND 9.	
										Total Amount pumped, corrected for Slip (Million Gallons).	Daily Average Amount pumped (Million Gallons).
October, . . . . .	Hrs. Min.										
November, . . . . .	59 30	25.54	24,890	2,125	8.5	1,026.11	113.51	97,020,000	99,020,000	-	-
	373 -	164.01	165,491	16,114	9.7	991.05	119.91	98,990,000	101,030,000	-	-
Total and average, . . . . .	432 30	189.55	190,381	18,239	9.6	995.64	119.05	98,740,000	100,770,000	-	-

[Engine No. 9, 3 per cent. allowed for slip.]

January, . . . . .	Hrs. Min.										
February, . . . . .	307 -	245.25	222,762	25,950	11.6	1,100.95	123.72	118,050,000	121,750,000	245.25	7.911
March, . . . . .	319 10	255.78	226,026	29,149	12.9	1,131.64	132.16	124,580,000	128,480,000	255.78	9.135
April, . . . . .	305 40	244.76	205,462	27,854	13.6	1,191.27	131.08	130,070,000	134,150,000	244.76	7.895
May, . . . . .	291 20	232.31	193,117	23,261	12.0	1,202.95	129.56	129,830,000	133,800,000	232.31	7.744
June, . . . . .	324 10	257.21	212,451	29,746	14.0	1,210.68	130.33	131,440,000	135,560,000	257.21	8.297
July, . . . . .	322 10	239.89	204,065	26,407	12.9	1,273.57	129.44	137,320,000	141,620,000	239.89	8.663
August, . . . . .	330 -	313.95	239,609	25,227	10.5	1,310.26	127.82	139,510,000	143,880,000	313.95	10.127
September, . . . . .	335 35	269.22	220,220	27,268	12.4	1,222.50	129.16	131,530,000	135,650,000	269.22	8.685
October, . . . . .	303 55	241.98	206,433	25,490	12.3	1,172.19	129.37	126,320,000	130,280,000	241.98	8.066
November, . . . . .	270 10	214.37	186,645	22,850	12.2	1,148.54	129.93	124,310,000	128,210,000	239.91	7.739
December, . . . . .	58 45	46.99	43,583	4,759	10.9	1,078.17	126.91	113,980,000	117,550,000	211.00	7.033
	293 55	236.49	214,137	24,616	11.5	1,104.39	128.03	117,800,000	121,490,000	236.49	7.629
Total and average, . . . . .	3,521 50	2,818.20	2,374,510	292,577	12.3	1,186.86	129.52	128,050,000	132,060,000	3,007.75	8.240



TABLE NO. 19. — *Average Daily Consumption of Water during the Year 1905, in the Cities and Towns supplied by the Metropolitan Water Works, including Boston, Somerville, Chelsea, Malden, Everett, Quincy, Medford, Melrose, Revere, Watertown, Arlington, Lexington, Milton, Stoneham, Winthrop, Swampscott, Belmont, Nahant and a Small Portion of Saugus. (For Consumption of Water in Whole Metropolitan Water District, see Table No. 23.)*

MONTH.	Average Daily Consumption (Gallons).	Estimated Population.	Consumption per Inhabitant (Gallons).
January, . . . . .	127,669,000	895,600	143
February, . . . . .	137,491,000	896,770	153
March, . . . . .	117,897,000	897,950	131
April, . . . . .	108,800,000	899,130	121
May, . . . . .	112,422,000	900,300	125
June, . . . . .	114,028,000	901,200	127
July, . . . . .	121,178,000	902,090	134
August, . . . . .	117,826,000	902,980	131
September, . . . . .	116,790,000	903,870	129
October, . . . . .	114,831,000	904,760	127
November, . . . . .	113,431,000	905,650	125
December, . . . . .	119,593,000	906,540	132
For the year, . . . . .	118,398,000	902,090	131

TABLE NO. 20. — *Average Daily Consumption of Water, in Gallons, from the Low-service System in 1905.*

MONTH.	SOUTHERN LOW SERVICE.	NORTHERN LOW SERVICE.	Total Low-service Consumption.
	Boston, excluding East Boston and Charlestown.	Portions of Charles- town, Somerville, Chelsea, Everett, Malden, Medford, East Boston and Arlington.	
January, . . . . .	52,070,000	33,044,000	85,114,000
February, . . . . .	54,276,000	37,050,000	91,326,000
March, . . . . .	47,677,000	29,048,000	76,725,000
April, . . . . .	44,059,000	25,071,000	69,130,000
May, . . . . .	45,206,000	25,220,000	70,426,000
June, . . . . .	45,685,000	24,977,000	70,662,000
July, . . . . .	47,229,000	27,784,000	75,013,000
August, . . . . .	46,466,000	28,119,000	74,585,000
September, . . . . .	46,001,000	27,896,000	73,897,000
October, . . . . .	44,628,000	27,802,000	72,430,000
November, . . . . .	44,925,000	26,813,000	71,738,000
December, . . . . .	47,487,000	28,958,000	76,445,000
For the year, . . . . .	47,106,000	28,436,000	75,542,000

TABLE NO. 21. — *Average Daily Consumption of Water, in Gallons, from the High-service and Extra High-service Systems in 1905.*

MONTH.	SOUTHERN HIGH SERVICE.	SOUTHERN EXTRA HIGH SERVICE.	NORTHERN HIGH SERVICE.	NORTHERN EXTRA HIGH SERVICE.
	Quincy, Water- town, Belmont and Portions of Boston and Milton.	Portions of Boston and Milton.	Revere, Winthrop, Swampscott, Nahant, Stoneham, Melrose, and Portions of Boston, Chelsea, Everett, Malden, Medford, Somerville and Saugus.	Lexington and Portion of Arlington.
January, . . . . .	33,539,000	555,000	7,956,000	505,000
February, . . . . .	35,985,000	567,000	9,077,000	536,000
March, . . . . .	32,218,000	555,000	7,898,000	501,000
April, . . . . .	30,898,000	541,000	7,709,000	522,000
May, . . . . .	32,401,000	662,000	8,315,000	618,000
June, . . . . .	33,328,000	668,000	8,733,000	637,000
July, . . . . .	34,593,000	769,000	10,040,000	763,000
August, . . . . .	33,234,000	673,000	8,679,000	655,000
September, . . . . .	33,470,000	655,000	8,146,000	622,000
October, . . . . .	33,629,000	677,000	7,508,000	587,000
November, . . . . .	33,436,000	654,000	7,062,000	541,000
December, . . . . .	34,345,000	646,000	7,633,000	524,000
For the year, . . . . .	33,409,000	636,000	8,226,000	585,000

TABLE No. 22. — Average Daily Consumption of Water in Cities and Towns supplied from Metropolitan Works, as measured by Venturi Meters in 1905.

City or town,	MONTH.	BOSTON.			SOMERVILLE.			MALDEN.			CHELSEA.			EVERETT.			QUINCY.			MEDFORD.		
		596,170.			69,510.			38,180.			37,390.			29,270.			28,100.			19,720.		
		GALLONS.		Per Capita.	GALLONS.		Per Capita.	GALLONS.		Per Capita.	GALLONS.		Per Capita.	GALLONS.		Per Capita.	GALLONS.		Per Capita.	GALLONS.		Per Capita.
		Per Day.		Per Day.		Per Day.		Per Day.		Per Day.		Per Day.		Per Day.		Per Day.		Per Day.		Per Day.		
January,	.	.	.	97,923,200	165	6,629,100	96	1,916,500	51	5,751,800	155	3,098,600	108	2,763,700	99	1,805,400	92					
February,	.	.	.	103,921,900	175	7,571,500	110	2,071,700	55	6,477,600	175	3,428,200	119	3,022,300	108	2,000,100	102					
March,	.	.	.	90,464,100	152	5,942,100	86	1,941,900	51	4,854,100	131	2,799,800	97	2,388,800	103	1,807,000	92					
April,	.	.	.	83,276,200	140	5,491,800	79	1,882,800	50	3,823,700	103	2,610,800	90	2,828,100	101	1,750,400	89					
May,	.	.	.	85,418,400	144	5,902,800	85	1,960,700	52	3,615,100	97	2,663,200	91	3,013,800	107	1,986,500	101					
June,	.	.	.	87,056,300	146	6,083,600	88	2,027,400	53	3,726,300	100	2,538,500	87	3,070,000	109	2,069,500	105					
July,	.	.	.	89,760,700	151	6,813,200	98	2,169,400	57	3,775,800	101	2,460,900	84	3,400,800	121	2,280,300	116					
August,	.	.	.	88,017,800	148	6,246,600	90	2,038,300	53	3,489,600	93	2,250,900	77	3,319,700	118	2,013,600	102					
September,	.	.	.	87,702,300	147	5,957,900	85	2,072,800	54	3,413,700	91	2,257,000	76	3,134,200	111	1,947,800	99					
October,	.	.	.	86,577,000	145	5,820,100	83	2,059,400	54	3,307,100	88	2,312,500	78	3,114,800	111	1,855,500	94					
November,	.	.	.	85,928,400	144	5,594,500	80	2,018,300	52	3,303,600	88	2,310,100	78	3,156,900	112	1,765,100	89					
December,	.	.	.	91,767,100	153	5,965,700	85	2,077,600	54	3,719,900	99	2,438,700	82	2,884,700	102	1,783,400	90					
For the year,	.	.	.	89,743,900	151	6,160,900	89	2,019,500	53	4,091,200	110	2,592,400	89	3,050,100	109	1,921,800	97					



TABLE No. 22 — Average Daily Consumption of Water in Cities and Towns, etc. — Continued.

City or town,	.	.	.	.	.	MELROSE.		REVERE.		WATERTOWN.		ARLINGTON.		MILTON.		WINTHROP.	
						14,350.		12,930.		11,300.		9,710.		7,060.		7,070.	
						GALLONS.		GALLONS.		GALLONS.		GALLONS.		GALLONS.		GALLONS.	
MONTH.						Per Day.	Per Capita.	Per Day.	Per Capita.	Per Day.	Per Capita.	Per Day.	Per Capita.	Per Day.	Per Capita.	Per Day.	Per Capita.
January,	.	.	.	.	.	1,494,600	105	1,090,400	86	654,000	50	735,500	77	270,800	39	769,000	110
February,	.	.	.	.	.	1,665,700	117	1,296,300	102	718,300	64	825,100	86	273,500	39	885,700	127
March,	.	.	.	.	.	1,561,400	109	989,100	77	737,800	66	728,500	76	281,800	40	737,700	105
April,	.	.	.	.	.	1,490,300	104	949,100	74	682,900	61	678,100	70	287,900	41	765,700	109
May,	.	.	.	.	.	1,587,500	111	968,700	75	790,700	70	836,500	86	338,200	52	810,900	115
June,	.	.	.	.	.	1,619,300	113	1,027,500	80	831,200	74	883,700	91	366,900	52	848,400	120
July,	.	.	.	.	.	1,745,700	122	1,161,000	90	934,200	83	1,131,000	116	435,100	62	1,024,700	145
August,	.	.	.	.	.	1,566,600	109	1,091,900	84	921,500	81	848,600	87	338,900	48	952,800	136
September,	.	.	.	.	.	1,636,900	114	1,001,300	77	890,800	79	756,100	78	320,400	45	809,000	114
October,	.	.	.	.	.	1,559,900	108	852,000	65	821,600	72	710,400	73	341,600	48	667,400	94
November,	.	.	.	.	.	1,580,800	109	801,100	61	756,000	66	635,800	65	280,900	40	621,700	87
December,	.	.	.	.	.	1,708,700	118	873,200	67	741,900	65	680,700	69	278,700	39	689,700	97
For the year,	.	.	.	.	.	1,601,100	112	1,006,800	78	790,700	70	787,700	81	320,900	46	798,300	113

TABLE NO. 22. — Average Daily Consumption of Water in Cities and Towns, etc. — Concluded.

City or town, . . . . .	STONEHAM.			BELMONT.			LEXINGTON.			NAHANT.			SWAMPSCOTT.			METROPOLITAN DISTRICT.		
	6,320.			4,370.			4,060.			1,840.			6,080.			903,430.		
	GALLONS.			GALLONS.			GALLONS.			GALLONS.			GALLONS.			GALLONS.		
MONTH.	Per Day.	Per Capita.		Per Day.	Per Capita.		Per Day.	Per Capita.		Per Day.	Per Capita.		Per Day.	Per Capita.		Per Day.	Per Capita.	
January, . . . . .	511,900	81	.	176,900	41	.	283,500	71	.	69,100	74	.	399,800	78	.	126,343,800	141	.
February, . . . . .	619,400	98	.	259,800	60	.	293,100	73	.	88,800	95	.	426,900	84	.	135,845,900	162	.
March, . . . . .	535,900	85	.	263,400	61	.	278,500	70	.	57,900	62	.	381,500	74	.	117,251,300	131	.
April, . . . . .	523,000	83	.	248,800	57	.	275,100	68	.	68,000	74	.	384,200	75	.	108,017,700	120	.
May, . . . . .	584,000	92	.	319,900	73	.	297,900	74	.	143,300	75	.	477,300	78	.	111,745,400	124	.
June, . . . . .	548,200	87	.	293,600	67	.	300,600	74	.	210,200	72	.	643,400	90	.	114,144,600	126	.
July, . . . . .	577,500	91	.	402,200	92	.	390,700	96	.	340,200	99	.	911,700	119	.	119,715,100	132	.
August, . . . . .	506,700	80	.	378,100	87	.	359,700	88	.	261,500	77	.	857,400	112	.	115,460,200	127	.
September, . . . . .	511,500	81	.	254,000	58	.	312,000	76	.	181,100	62	.	600,400	83	.	113,759,200	125	.
October, . . . . .	449,800	71	.	224,300	51	.	305,100	74	.	89,500	47	.	458,200	74	.	111,526,200	123	.
November, . . . . .	405,200	64	.	208,800	48	.	266,800	65	.	64,300	71	.	379,200	73	.	110,077,500	122	.
December, . . . . .	402,300	64	.	163,700	37	.	224,800	54	.	59,600	66	.	480,400	92	.	116,940,800	129	.
For the year, . . . . .	514,000	81	.	266,300	61	.	299,100	74	.	136,600	74	.	534,600	88	.	116,635,900	129	.

TABLE NO. 23. — *Consumption of Water in the Metropolitan Water District, as constituted in the Year 1905, the Town of Swampscott and a Small Section of the Town of Saugus, from 1893 to 1905.*

[Gallons per Day.]

MONTH.	1893.	1894.	1895.	1896.	1897.	1898.	1899.
January, . . . . .	75,209,000	67,506,000	68,925,000	82,946,000	85,366,000	83,880,000	96,442,000
February, . . . . .	71,900,000	68,944,000	80,375,000	87,021,000	83,967,000	87,475,000	103,454,000
March, . . . . .	67,638,000	62,710,000	69,543,000	86,111,000	82,751,000	85,468,000	90,200,000
April, . . . . .	62,309,000	57,715,000	62,909,000	77,529,000	79,914,000	76,574,000	86,491,000
May, . . . . .	61,025,000	60,676,000	65,194,000	73,402,000	76,772,000	76,677,000	89,448,000
June, . . . . .	63,374,000	63,329,000	69,905,000	77,639,000	77,952,000	83,463,000	97,691,000
July, . . . . .	69,343,000	73,642,000	69,667,000	80,000,000	85,525,000	88,228,000	96,821,000
August, . . . . .	66,983,000	67,995,000	72,233,000	78,537,000	84,103,000	87,558,000	92,072,000
September, . . . . .	64,654,000	67,137,000	73,724,000	74,160,000	84,296,000	88,296,000	91,478,000
October, . . . . .	63,770,000	62,735,000	67,028,000	71,762,000	79,551,000	81,770,000	89,580,000
November, . . . . .	61,204,000	62,231,000	64,881,000	71,933,000	72,762,000	78,177,000	86,719,000
December, . . . . .	66,700,000	65,103,000	70,443,000	79,449,000	76,594,000	86,355,000	85,840,000
Average for the year, .	66,165,000	65,382,000	69,499,000	78,360,000	80,793,000	83,651,000	92,111,000
Population, . . . . .	723,153	743,354	763,557	786,385	809,213	832,042	854,870
Consumption per inhabitant,	91.5	88.0	91.0	99.7	99.8	100.5	107.8

MONTH.	1900.	1901.	1902.	1903.	1904.	1905.
January, . . . . .	100,055,000	111,275,000	118,435,000	125,176,000	137,771,000	130,878,000
February, . . . . .	98,945,000	117,497,000	117,268,000	122,728,000	143,222,000	140,595,000
March, . . . . .	97,753,000	105,509,000	108,461,000	111,977,000	123,334,000	120,879,000
April, . . . . .	89,497,000	93,317,000	103,153,000	107,179,000	108,688,000	111,898,000
May, . . . . .	87,780,000	95,567,000	106,692,000	111,589,000	111,715,000	115,804,000
June, . . . . .	98,581,000	103,420,000	110,002,000	105,590,000	111,209,000	117,441,000
July, . . . . .	107,786,000	106,905,000	103,340,000	107,562,000	113,584,000	124,769,000
August, . . . . .	102,717,000	102,815,000	107,045,000	103,570,000	112,836,000	121,158,000
September, . . . . .	103,612,000	102,103,000	107,752,000	106,772,000	114,188,000	120,103,000
October, . . . . .	98,358,000	103,389,000	106,560,000	103,602,000	108,290,000	118,301,000
November, . . . . .	93,648,000	101,324,000	105,175,000	103,477,000	108,054,000	116,693,000
December, . . . . .	97,844,000	113,268,000	125,434,000	114,721,000	125,119,000	122,696,000
Average for the year, .	98,059,000	104,645,000	110,345,000	110,277,000	118,114,000	121,671,000
Population, . . . . .	877,698	892,740	907,780	922,820	937,860	953,556
Consumption per inhabitant,	111.7	117.2	121.6	119.5	125.9	127.6

This table includes the water consumed in the cities and towns enumerated in Table No. 19, together with the water consumed in Newton and Hyde Park, which are included in the Metropolitan Water District but have not been supplied from the Metropolitan Works. The populations for the years 1901 to 1904 have been revised since the census of 1905 became available, and consequently differ from those published in a corresponding table in the preceding annual report.



TABLE NO. 24. — Chemical Examinations of Water from the Wachusett Reservoir, Clinton.  
[Parts per 100,000.]

Number.	Date of Collection.	APPEARANCE.				ODOR.		RESIDUE ON EVAPORA- TION.		AMMONIA.				NITROGEN AS		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	COLOR.		Cold.	Hot.	Total.	Loss on Ignition.	Free.	ALBUMINOID.		Nitrates.	Nitrites.			
				Nessler Standard	Platinum Stand- ard.						Total.	Dissolved.			Suspended.		
52607	1905. Jan. 2	Slight.	Slight.	.18	24	Faintly unpleasant.	Faintly unpleasant.	3.70	1.50	.0048	.0280	.0222	.0058	.0030	.0002	.39	1.4
52872	Feb. 7	V. slight.	V. slight.	.21	27	None.	Faintly unpleasant.	3.45	1.40	.0044	.0132	.0118	.0014	.0040	.0002	.35	1.1
53118	March 6	V. slight.	V. slight.	.29	32	None.	Faintly vegetable.	4.00	1.75	.0052	.0138	.0110	.0028	.0080	.0001	.43	1.1
53560	April 3	Slight.	V. slight.	.29	32	None.	None.	3.50	0.95	.0032	.0118	.0104	.0014	.0140	.0001	.44	0.8
53928-48	May 1-2	Decided.	Cons.	.27	31	Faintly vegetable and unpleasant.	Faintly vegetable and unpleasant.	2.80	1.05	.0025	.0149	.0113	.0036	.0090	.0001	.36	0.7
54602-92	June 6-13	V. slight.	Slight.	.23	28	V. faintly unpleasant.	Faintly unpleasant.	2.77	1.15	.0044	.0135	.0108	.0027	.0075	.0001	.31	0.4
55117	July 3	V. slight.	V. slight.	.20	26	Faintly vegetable.	Faintly vegetable.	2.60	0.95	.0026	.0134	.0108	.0026	.0010	.0000	.26	0.6
55727	Aug. 1	V. slight.	Slight.	.15	22	Faintly vegetable.	Faintly vegetable.	2.60	1.05	.0012	.0126	.0110	.0016	.0020	.0001	.26	0.8
56517	Sept. 6	V. slight.	Slight.	.12	20	V. faintly vegetable.	Faintly vegetable.	4.95	2.35	.0028	.0128	.0112	.0016	.0020	.0001	.27	0.5
57353	Oct. 10	V. slight.	Slight.	.21	27	Faintly vegetable.	Distinctly vegetable.	3.10	1.20	.0010	.0160	.0136	.0024	.0020	.0000	.34	1.0
57939	Nov. 7	V. slight.	Cons.	.16	23	Faintly vegetable.	Distinctly vegetable.	2.85	1.20	.0002	.0136	.0106	.0030	.0010	.0000	.40	1.3
58478	Dec. 5	V. slight.	Slight.	.20	26	V. faintly vegetable.	V. faintly vegetable.	3.15	1.05	.0010	.0162	.0136	.0026	.0080	.0001	.35	0.8
Av. .	.....	.....	.....	.21	27	.....	.....	3.29	1.30	.0028	.0150	.0124	.0026	.0051	.0001	.35	0.9

TABLE NO. 25. — *Chemical Examinations of Water from Sudbury Reservoir.*  
[Parts per 100,000.]

Number.	Date of Collection.	APPEARANCE.				ODOR.		RESIDUE ON EVAPORA- TION.		AMMONIA.				NITROGEN AS		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	COLOR.		Cold.	Hot.	Total.	Loss on Ignition.	Free.	ALBUMINOID.		Chlorine.	Nitrates.	Nitrites.		
				Transformed to Platinum Blend.	Nessler Blend.						Total	Dissolved.					
52657	1905. Jan. 10	None.	None.	.16	23	None.	Faintly vegetable.	3.20	1.90	.0070 .0218	-	-	.37	.0050 .0000	.30	1.1	
52876	Feb. 7	V. slight.	V. slight.	.27	31	Faintly unpleasant.	Faintly unpleasant.	4.30	1.65	.0072 .0172	.0162	.0010	.32	.0120 .0002	.52	1.4	
53566	April 4	V. slight.	V. slight.	.23	28	V. faintly vegetable.	V. faintly vegetable.	4.15	1.60	.0052 .0116	.0102	.0014	.31	.0200 .0002	.36	1.3	
54599	June 6	V. slight.	Cons.	.23	28	V. faintly vegetable.	Faintly vegetable.	3.25	1.30	.0024 .0162	.0130	.0032	.26	.0040 .0001	.33	1.1	
55671	July 31	Slight.	Slight.	.13	20	Faintly vegetable.	Distinctly vegetable.	3.10	1.20	.0014 .0118	.0104	.0014	.25	.0020 .0001	.25	0.8	
57210	Oct. 3	V. slight.	Slight.	.17	24	Faintly vegetable.	Distinctly vegetable and sweetish.	3.40	1.65	.0046 .0168	.0138	.0030	.28	.0010 .0000	.35	0.8	
58463	Dec. 5	V. slight.	Cons.	.16	23	None.	Faintly vegetable.	3.15	1.40	.0012 .0144	.0116	.0028	.28	.0050 .0000	.29	1.0	
Av.	.....	.....	.....	.19	26	.....	.....	3.71	1.53	.0041 .0126	.0125	.0021	.30	.0070 .0001	.34	1.1	

TABLE No. 26. — *Chemical Examinations of Water from Spot Pond, Stoneham.*

[Parts per 100,000 ]

Number.	Date of Collection.	APPEARANCE.			ODOR.		RESIDUE ON EVAPORA- TION.		AMMONIA.				NITROGEN AS		Oxygen Consumed.	Hardness.		
		Turbidity.	Sediment.	COLOR.		Cold.	Hot.	Total.	Loss on Ignition.	Free.	ALBUMINOID.			Nitrates.			Nitrites.	
				Nessler Standard.	Transformed to Platinum Stand- ard.						Total.	Dissolved.	Suspended.					
52709	1905. Jan. 16	V. slight.	Slight.	.20	26	Faintly unpleasant.	Faintly unpleasant.	4.05	1.35	.0018	.0186	.0174	.0012	.46	.0010	.0001	.42	1.5
52902	Feb. 13	V. slight.	Slight.	.18	24	Faintly vegetable.	Faintly unpleasant.	4.00	1.35	.0056	.0206	.0194	.0012	.41	.0020	.0001	.34	1.6
53546	April 3	V. slight.	V. slight.	.16	23	Faintly vegetable.	Faintly unpleasant.	3.85	1.75	.0010	.0126	.0098	.0028	.32	.0100	.0002	.29	1.4
54485	June 5	V. slight.	Cons.	.15	22	V. faintly unpleasant.	Faintly unpleasant.	3.40	1.10	.0010	.0188	.0136	.0052	.30	.0010	.0002	.30	1.4
55713	Aug. 1	V. slight organisms	Slight or- ganisms.	.15	22	V. faintly unpleasant.	Faintly unpleasant.	4.15	1.65	.0010	.0140	.0120	.0020	.33	.0010	.0001	.22	1.3
57314	Oct. 9	V. slight.	Slight.	.11	19	None.	V. faintly vegetable.	3.60	1.20	.0016	.0152	.0138	.0014	.34	.0000	.0000	.24	1.3
58422	Dec. 4	None.	Slight.	.19	26	V. faintly unpleasant.	V. faintly unpleasant.	3.55	1.45	.0026	.0202	.0176	.0026	.31	.0000	.0000	.30	1.1
Av.	.....	.....	.....	.16	23	.....	.....	3.80	1.41	.0021	.0171	.0148	.0022	.35	.0021	.0001	.30	1.4



TABLE NO. 27. — *Chemical Examinations of Water from Lake Cochituate.*  
[Parts per 100,000.]

Number.	Date of Collection.	APPEARANCE.			ODOR.		RESIDUE ON EVAPORATION.			AMMONIA.			NITROGEN AS		Oxygen Consumed.	Hardness.		
		Turbidity.	Sediment.	COLOR.	Cold.	Hot.	Total.	Loss on Ignition.	Free.	ALBUMINOID.		Nitrates.	Nitrite.					
										Dissolved.	Suspended.			Chlorine.				
52649	1905. Jan. 9	Slight.	V. slight.	.32	34	Faintly fishy, uroglena.	Decidedly fishy, uroglena.	4.35	1.60	.0008	.0184	.0146	.0038	.50	.0110	.0001	.43	1.7
52887	Feb. 8	Slight.	Cons.	.42	40	Decidedly cucumber, synura.	Strong cucumber, synura.	5.60	2.00	.0064	.0286	.0194	.0092	.51	.0080	.0001	.56	1.9
53109	March 6	V. slight.	V. slight.	.33	35	Faintly vegetable and unpleasant	Faintly vegetable and unpleasant.	5.00	1.85	.0038	.0192	.0166	.0026	.52	.0080	.0001	.49	1.9
53350	April 3	V. slight.	V. slight.	.29	32	V. faintly vegetable.	Faintly vegetable, cucumber, synura.	4.45	1.65	.0008	.0140	.0128	.0012	.48	.0100	.0001	.40	2.1
53926	May 1	Slight.	Slight.	.27	31	V. faintly vegetable.	Faintly vegetable.	4.30	1.70	.0030	.0206	.0178	.0028	.48	.0040	.0001	.46	1.8
54550	June 5	V. slight.	Cons.	.23	28	Faintly vegetable and unpleasant.	Faintly vegetable and unpleasant.	4.75	1.65	.0064	.0236	.0194	.0042	.48	.0020	.0001	.39	1.8
55089	July 3	V. slight.	Slight, also scum.	.20	26	Faintly unpleasant.	Distinctly oily, uroglena.	4.45	2.05	.0006	.0236	.0154	.0082	.46	.0020	.0001	.40	1.4
55660	July 31	V. slight.	Slight.	.20	26	V. faintly vegetable.	Faintly vegetable.	4.60	1.90	.0010	.0210	.0176	.0034	.48	.0020	.0000	.36	1.4
56501	Sept. 5	V. slight.	Slight.	.14	21	Faintly vegetable.	Faintly vegetable.	4.65	1.75	.0024	.0244	.0170	.0074	.51	.0010	.0001	.31	1.8
57143	Oct. 2	Slight.	Cons.	.18	24	Faintly vegetable and distinctly unpleasant.	Faintly vegetable and distinctly unpleasant.	5.05	1.80	.0012	.0236	.0188	.0048	.53	.0040	.0002	.44	2.0
57941	Nov. 7	V. slight.	Slight.	.21	27	Distinctly vegetable.	Distinctly vegetable and faintly unpleasant.	5.55	2.20	.0018	.0176	.0144	.0032	.50	.0020	.0000	.39	2.2
58448	Dec. 4	V. slight.	Slight.	.22	27	Faintly vegetable.	Faintly vegetable.	5.00	1.60	.0020	.0206	.0154	.0052	.52	.0010	.0001	.41	1.8
Av.	.....	.....	.....	.25	29	.....	.....	4.81	1.81	.0025	.0213	.0166	.0047	.50	.0046	.0001	.42	1.8

TABLE No. 28. — Chemical Examinations of Water from a Faucet at the State House, Boston.

[Parts per 100,000.]

AND SEWERAGE BOARD.

Number.	Date of Collection.	APPEARANCE.			ODOR.		RESIDUE ON EVAPORA- TION.		AMMONIA.				NITROGEN AS		Oxygen Consumed.	Hardness.	
		Turbidity.	Sediment.	COLOR.	Cold.	Hot.	Total.	Loss on Ignition.	Free.	ALBUMINOID.			Nitrates.	Nitrites.			
										Total.	Dissolved.	Suspended.					
1905.																	
52613	Jan. 9	V. slight.	V. slight.	.24	Faintly vegetable.	Distinctly vegetable.	3.80	1.40	.0030	.0112	.0110	.0002	.30	.0060	.0000	.39	1.1
52870	Feb. 7	V. slight.	V. slight.	.20	Faintly vegetable.	Faintly vegetable and un-pleasant, synura.	3.25	1.35	.0042	.0112	.0108	.0004	.31	.0080	.0001	.28	1.3
53096	March 6	V. slight.	V. slight.	.34	Faintly vegetable.	Distinctly vegetable.	3.90	1.70	.0038	.0118	.0112	.0006	.38	.0100	.0001	.46	1.4
53536	April 3	V. slight.	V. slight.	.26	V. faintly vegetable.	V. faintly vegetable.	3.85	1.45	.0018	.0148	.0114	.0034	.35	.0150	.0002	.36	1.3
53910	May 1	V. slight.	V. slight.	.22	None.	Faintly vegetable.	3.95	1.40	.0020	.0126	.0110	.0016	.37	.0130	.0000	.39	1.6
54482	June 5	Slight.	Slight.	.23	V. faintly unpleasant.	Faintly unpleasant.	3.80	1.45	.0014	.0166	.0112	.0054	.29	.0100	.0001	.30	1.3
55066	July 3	V. slight.	V. slight.	.25	Faintly vegetable.	Distinctly vegetable.	3.10	1.30	.0008	.0140	.0120	.0020	.27	.0120	.0001	.38	1.1
55653	July 31	V. slight.	V. slight.	.20	V. faintly vegetable.	Faintly vegetable.	3.95	1.80	.0006	.0154	.0144	.0010	.38	.0040	.0001	.33	1.4
56492	Sept. 5	V. slight.	Slight.	.21	Faintly sweetish.	Distinctly vegetable, sweetish.	4.00	1.90	.0016	.0174	.0162	.0012	.38	.0040	.0002	.37	1.4
57122	Oct. 2	V. slight.	Slight.	.20	Faintly vegetable.	Distinctly vegetable.	4.15	1.80	.0018	.0200	.0142	.0058	.42	.0060	.0001	.31	1.4
57944	Nov. 8	V. slight.	Slight.	.23	Faintly vegetable.	Faintly vegetable.	4.70	1.95	.0014	.0148	.0136	.0012	.43	.0030	.0000	.32	1.7
58406	Dec. 4	V. slight.	Slight.	.27	Faintly vegetable and distinctly unpleasant.	Faintly vegetable and distinctly unpleasant.	4.15	1.55	.0020	.0176	.0140	.0036	.42	.0030	.0002	.43	1.4
Av.	.....	.....	.....	.24	.....	.....	3.89	1.67	.0020	.0148	.0126	.0022	.36	.0078	.0001	.36	1.4

TABLE NO. 29. — Averages of Examinations of Water from Various Parts of the Metropolitan Water Works in 1905.

[Parts per 100,000.]

LOCALITY.	Samples Collected.	COLOR.		RESIDUE ON EVAPORATION.		AMMONIA.				NITROGEN AS		Oxygen Consumed.	Hardness.
		Nessler Standard.	Transformed to Platinum Standard.	Total.	Loss on Ignition.	Free.	ALBUMINOID.			Nitrates.	Nitriles.		
							Total.	Dissolved.	Suspended.				
Quinepoxet River, Holden, . . . .	Bi-monthly, .	.54	48	3.98	1.69	.0056	.0208	.0168	.0040	.0070	.0001	.66	0.6
Stillwater River, Sterling, . . . .	Bi-monthly, .	.44	42	3.15	1.38	.0027	.0153	.0138	.0016	.0043	.0001	.54	0.7
Wachusett Reservoir, West Boylston, .	Monthly, .	.55	49	3.74	1.73	.0023	.0205	.0168	.0038	.0059	.0001	.60	0.8
Wachusett Reservoir, Clinton, surface, .	Monthly, .	.21	27	3.29	1.30	.0028	.0150	.0124	.0026	.0051	.0001	.35	0.9
Wachusett Reservoir, Clinton, El. 288, .	Monthly, .	.21	27	3.06	1.05	.0025	.0123	.0102	.0021	.0070	.0001	.32	0.7
Marlborough (Walker's) Brook, . . .	Bi-monthly, .	.61	53	16.60	5.12	.2197	.0435	.0307	.0128	.1421	.0047	.83	5.7
Marlborough Brook filter-beds, effluent, .	Bi-monthly, .	.23	28	14.80	-	.1047	.0162	-	-	.1750	.0004	.37	5.1
Wachusett Aqueduct, Southborough, .	Bi-monthly, .	.40	39	3.96	1.63	.0034	.0188	.0166	.0021	.0112	.0001	.55	1.1
Sudbury Reservoir, surface, . . . .	Bi-monthly, .	.19	26	3.71	1.53	.0041	.0126	.0125	.0021	.0070	.0001	.34	1.1
Framingham Reservoir, No. 3, near dam, .	Bi-monthly, .	.19	26	3.23	1.18	.0028	.0150	.0121	.0029	.0053	.0002	.30	1.2
Hopkinton Reservoir, inlet, . . . .	Bi-monthly, .	1.45	112	6.28	3.43	.0039	.0335	.0317	.0030	.0050	.0001	1.54	1.4
Hopkinton Reservoir, surface, . . . .	Bi-monthly, .	.61	53	4.00	1.89	.0049	.0189	.0164	.0025	.0102	.0002	.73	0.9



TABLE NO. 29. — Averages of Examinations of Water, etc. — Concluded.

[Parts per 100,000.]

LOCALITY.	Samples Collected.	COLOR.		RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.
		Nessler Standard.	Transformed to Platinum Standard.	Total.	Loss on Ignition.	Free.	Total.	Dis-solved.	Sus-pended.		Nitrates.	Nitrites.		
Ashland Reservoir, inlet, . . . . .	Bi-monthly,	1.12	89	4.95	2.55	.0032	.0309	.0259	.0050	.32	.0048	.0001	1.10	0.9
Ashland Reservoir, surface, . . . . .	Bi-monthly,	.67	56	4.06	1.95	.0030	.0212	.0190	.0022	.31	.0055	.0001	.68	1.0
Framingham Reservoir No. 2, inlet, . . . . .	Bi-monthly,	.71	58	4.84	2.37	.0040	.0249	.0217	.0033	.37	.0115	.0002	.78	1.1
Framingham Reservoir No. 2, near dam, . . . . .	Bi-monthly,	.76	61	4.37	2.00	.0044	.0222	.0201	.0021	.34	.0055	.0002	.83	1.0
Lake Cochituate, . . . . .	Monthly, .	.25	29	4.81	1.81	.0025	.0213	.0166	.0047	.50	.0046	.0001	.42	1.8
Terminal chamber, Sudbury Aqueduct, . . . . .	Bi-monthly,	.23	28	3.49	1.44	.0035	.0161	.0131	.0031	.29	.0061	.0001	.34	1.1
Spot Pond, . . . . .	Bi-monthly,	.16	23	3.80	1.41	.0021	.0171	.0148	.0022	.35	.0021	.0001	.30	1.4
Tap in Revere, . . . . .	Bi-monthly,	.14	21	3.43	1.27	.0019	.0139	.0121	.0019	.32	.0034	.0000	.26	1.4
Tap at State House, . . . . .	Monthly, .	.24	29	3.89	1.67	.0020	.0148	.0126	.0022	.36	.0078	.0001	.36	1.4
Tap in Quincy, . . . . .	Bi-monthly,	.20	26	3.83	1.41	.0017	.0135	.0120	.0015	.34	.0103	.0001	.34	1.5

TABLE NO. 30.—*Chemical Examinations of Water from a Faucet in Boston, from 1892 to 1905.*

[Parts per 100,000.]

YEAR.	COLOR.		RESIDUE ON EVAPORATION.		AMMONIA.				Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.
	Nessler Standard.	Platinum Standard.	Total.	Loss on Ignition.	Free.	ALBUMINOID.		Nitrates.		Nitrites.			
						Total.	Dissolved.				Suspended.		
1892, .	.37	37	4.70	1.67	.0007	.0168	.0138	.0030	.41	.0210	.0001	-	1.9
1893, .	.61	53	4.54	1.84	.0010	.0174	.0147	.0027	.38	.0143	.0001	.60	1.8
1894, .	.69	58	4.64	1.83	.0006	.0169	.0150	.0019	.41	.0106	.0001	.63	1.7
1895, .	.72	59	4.90	2.02	.0006	.0197	.0175	.0022	.40	.0171	.0001	.69	0.7
1896, .	.49	45	4.29	1.67	.0005	.0165	.0142	.0023	.37	.0155	.0001	.56	1.4
1897, .	.65	55	4.82	1.84	.0009	.0193	.0177	.0016	.40	.0137	.0001	.64	1.6
1898, .	.41	40	4.19	1.60	.0008	.0152	.0136	.0016	.29	.0097	.0001	.44	1.4
1899, .	.23	28	3.70	1.30	.0006	.0136	.0122	.0014	.24	.0137	.0001	.35	1.1
1900, .	.24	29	3.80	1.20	.0012	.0157	.0139	.0018	.25	.0076	.0001	.38	1.3
1901, .	.24	29	4.43	1.64	.0013	.0158	.0142	.0016	.30	.0173	.0001	.42	1.7
1902, .	.26	30	3.93	1.56	.0016	.0139	.0119	.0020	.29	.0092	.0000	.40	1.3
1903, .	.25	29	3.98	1.50	.0013	.0125	.0110	.0015	.30	.0142	.0001	.39	1.5
1904, .	.23	28	3.93	1.59	.0023	.0139	.0121	.0018	.34	.0110	.0001	.37	1.5
1905, .	.24	29	3.89	1.67	.0020	.0148	.0126	.0022	.36	.0078	.0001	.36	1.4

*Note relating to Chemical Examinations of Water, Tables Nos. 24-30.*

The chemical examinations contained in the tables were made by the State Board of Health. Colors have been determined by the Nessler standard, but the corresponding values by the platinum standard are also given, for the purpose of comparison with colors determined in the laboratory of the Metropolitan Water and Sewerage Board, as given in subsequent tables. The odor recorded is taken in such a way that it is a much stronger odor than would be noticed in samples drawn directly from a tap or collected directly from a reservoir. The more important samples are collected and examined monthly; those of less significance, at intervals of two or three months.

TABLE NO. 31.— Colors of Water from Various Parts of the Metropolitan Water Works in 1905. (Means of Weekly Determinations.)

[Platinum Standard.]

MONTH.	WACHUSETT RESERVOIR.					SUDBURY RESERVOIR.				FRAMINGHAM RESERVOIR No. 3.	SPOT POND.	FELLS RESERVOIR.
	Surface.	Mid-depth.	Bottom.	Worcester Street Bridge.	Aqueduct Head House	Surface.	Mid-depth.	Bottom.	End of Open Channel.	Mid-depth.	Mid-depth.	Effluent Gate-house.
January, . . . . .	-	-	-	-	26	24	21	20	55	22	21	20
February, . . . . .	-	-	-	-	32	34	28	26	34	24	21	21
March, . . . . .	-	-	-	-	41	26	30	31	71	29	25	22
April, . . . . .	-	-	-	-	39	29	29	29	88	31	24	22
May, . . . . .	33	34	35	43	35	34	34	34	36	32	23	21
June, . . . . .	28	28	28	45	28	27	27	27	50	27	20	21
July, . . . . .	23	23	24	49	23	20	21	22	24	22	18	17
August, . . . . .	21	25	23	47	21	19	19	20	22	20	16	15
September, . . . . .	20	21	24	66	21	18	18	18	106	24	17	15
October, . . . . .	25	25	26	40	25	23	23	24	26	24	17	15
November, . . . . .	23	23	24	47	23	23	23	23	26	23	18	16
December, . . . . .	23	24	24	59	24	22	22	22	43	21	18	15
Mean, . . . . .	-	-	-	-	28	25	25	24	48	25	20	18

TABLE NO. 31— Concluded.

[Platinum Standard.]

MONTH.	LAKE COCHITUATE.				CHESTNUT HILL RESERVOIR.			NORTHERN SERVICE.		SOUTHERN SERVICE.	
	Surface.	Mid-depth.	Bottom.	Influent Streams. <sup>1</sup>	Inlet (Sudbury Aqueduct).	Inlet (Cochituate Aqueduct).	Effluent Gate-house No. 2.	Tap at Glenwood Yard, Medford (Low Service).	Tap at Hancock Street, Fire Station, Everett (High Service).	Tap at 244 Boylston Street, Boston (Low Service).	Tap at 1 Ashburton Place, Boston (High Service).
January, . . . . .	41	29	31	73	25	-	27	27	21	25	28
February, . . . . .	47	28	30	71	29	34	26	25	20	25	26
March, . . . . .	38	29	31	75	36	40	39	37	25	37	37
April, . . . . .	36	36	36	84	32	35	32	28	22	30	32
May, . . . . .	33	32	34	100	33	32	29	29	21	31	31
June, . . . . .	28	29	36	108	34	25	31	31	21	31	31
July, . . . . .	23	28	40	96	32	22	30	31	17	26	29
August, . . . . .	20	25	43	57	36	21	29	28	16	26	26
September, . . . . .	23	28	102	59	25	23	27	26	17	23	27
October, . . . . .	27	30	126	89	30	25	27	26	19	27	27
November, . . . . .	28	28	47	88	37	28	35	37	18	28	33
December, . . . . .	27	28	31	83	34	27	33	34	18	29	31
Mean, . . . . .	31	29	49	82	32	-	30	30	20	28	30

<sup>1</sup> The colors given in this column represent the combined colors of the waters of the four principal feeders. The color of each is determined monthly, and due weight is given, in combining the results, to the sizes of the streams.



TABLE NO. 32. — *Temperatures of Water from Various Parts of the Metropolitan Water Works in 1905. (Means of Weekly Determinations.)*

[The temperatures are taken at the same places and times as the samples for microscopical examination ; the depth given for each reservoir is the depth from high water mark.]

[Degrees Fahrenheit.]

MONTH.	WACHUSETT RESERVOIR.			SUDBURY RESERVOIR (DEPTH AT PLACE OF OBSERVATION 54.5 FEET).				FRAMINGHAM RESERVOIR No. 3 (DEPTH AT PLACE OF OBSERVATION 20.5 FEET).			LAKE COCHITUATE (DEPTH AT PLACE OF OBSERVATION 62.0 FEET).		
	Surface.	Mid-depth.	Bottom.	Surface.	Mid depth.	Bottom.	End of Open Channel.	Surface.	Mid-depth.	Bottom.	Surface.	Mid-depth.	Bottom.
January, .	-	-	-	34.2	37.0	38.0	35.2	36.0	36.0	36.0	33.2	35.2	36.2
February, .	-	-	-	32.6	35.0	36.1	34.3	35.0	36.1	36.4	32.8	36.1	37.5
March, .	-	-	-	33.6	34.9	36.0	35.3	35.5	36.2	36.9	34.9	37.2	37.8
April, .	-	-	-	42.8	42.3	42.3	44.9	45.1	45.1	45.1	42.3	43.5	42.3
May, .	58.5	55.6	53.8	58.2	57.0	55.9	54.9	58.5	58.4	57.2	58.1	50.8	45.9
June, .	67.0	63.3	60.0	67.8	64.9	62.8	65.8	67.6	67.5	65.3	69.6	54.6	47.5
July, .	77.3	69.4	65.2	76.0	71.8	69.3	75.8	77.7	76.9	76.6	74.8	53.8	48.0
August, .	70.8	67.6	62.3	75.4	71.3	67.8	71.9	73.3	72.9	72.7	73.1	54.0	49.3
September, .	66.3	65.1	61.1	66.8	66.5	66.0	65.9	65.9	65.8	65.8	66.3	53.8	46.8
October, .	58.7	55.6	50.8	57.8	58.4	58.3	57.4	56.8	57.0	57.1	58.9	54.9	46.5
November, .	45.3	45.1	45.0	44.4	44.9	45.3	44.3	41.3	42.1	41.1	44.9	45.4	44.3
December, .	37.5	37.5	36.7	38.3	38.8	39.4	37.9	35.3	36.5	36.6	37.1	38.5	39.3
Mean, .	-	-	-	52.3	51.9	51.4	52.0	52.3	52.5	52.2	52.2	46.5	43.5

TABLE NO. 32 — *Concluded.*

[Degrees Fahrenheit.]

MONTH.	CHESTNUT HILL RESERVOIR.	SPOT POND (DEPTH AT PLACE OF OBSERVATION 28.0 FEET).			NORTHERN SERVICE.		SOUTHERN SERVICE.	
	Effluent Gate-house No. 2.	Surface.	Mid-depth.	Bottom.	Tap at Glenwood Yard, Medford (Low Service).	Tap at 44 Clarendon Street, Malden (High Service).	Tap at 244 Boylston Street, Boston (Low Service).	Tap at 1 Ashburton Place, Boston (High Service).
January, .	35.4	36.2	36.6	37.4	37.5	38.9	37.9	38.0
February, .	35.4	36.8	37.6	38.5	36.4	36.0	38.0	37.8
March, .	37.1	37.0	37.8	38.5	38.9	38.6	38.4	38.9
April, .	45.6	43.4	43.4	43.4	43.4	43.4	46.4	46.2
May, .	58.6	57.0	56.6	56.1	54.3	53.1	58.4	58.3
June, .	68.3	66.5	65.6	62.0	62.8	64.9	66.3	67.3
July, .	75.0	74.6	73.0	64.3	70.9	71.5	71.2	74.5
August, .	72.4	72.7	72.4	67.6	68.8	71.3	72.4	73.0
September, .	66.9	66.6	66.6	66.4	65.3	66.0	67.0	67.3
October, .	58.8	58.1	58.0	58.1	59.1	59.0	62.0	60.9
November, .	44.8	44.5	44.5	44.5	47.5	46.1	47.4	48.2
December, .	37.5	36.0	36.3	36.5	40.9	39.0	41.9	42.2
Mean, .	53.0	52.5	52.4	51.1	52.0	52.3	53.9	54.4

TABLE NO. 33.— *Temperatures of the Air at Three Stations on the Metropolitan Water Works in 1905.*

[Degrees Fahrenheit.]

MONTH.	CHESTNUT HILL RESERVOIR.			FRAMINGHAM.			CLINTON.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
January, . . . .	50.5	—3.5	23.5	56.0	—9.0	22.8	48.0	—6.0	20.6
February, . . . .	45.0	—2.0	21.2	54.0	—8.0	20.7	42.5	—4.5	17.9
March, . . . . .	71.5	9.0	35.7	69.0	5.0	34.1	69.0	7.0	32.4
April, . . . . .	77.0	27.0	47.9	78.0	24.0	48.2	77.0	26.0	45.4
May, . . . . .	85.0	32.5	56.8	83.0	29.0	57.8	81.0	32.0	56.7
June, . . . . .	92.0	38.5	64.8	90.0	35.0	63.9	89.0	37.5	64.2
July, . . . . .	95.5	50.0	73.2	93.0	50.0	71.0	90.0	50.0	71.1
August, . . . . .	92.0	46.0	68.4	88.0	41.0	65.8	85.5	41.5	65.9
September, . . . .	82.0	33.0	61.9	80.0	30.0	59.4	77.0	34.5	59.8
October, . . . . .	80.0	25.0	52.5	79.0	20.0	50.4	81.5	20.0	50.4
November, . . . .	65.0	12.0	40.2	66.0	10.0	36.9	61.0	11.5	37.4
December, . . . .	60.0	9.0	33.0	58.0	2.0	30.9	58.0	—2.5	29.9
Average, . . . .	-	-	48.3	-	-	46.8	-	-	46.0

TABLE NO. 34.— *Table showing Length of Main Lines of Water Pipes and Connections owned and operated by Metropolitan Water and Sewerage Board, and Number of Valves set in Same.*

	DIAMETER OF PIPES IN INCHES.													Total.
	60	48	42	36	30	24	20	16	14	12	10	8	6	
Total length owned and operated January 1, 1905 (feet),	9,069	171,100	8,075	46,626	26,922	46,651	57,038	54,394	26	21,609	614	1,597	858	444,629
Gate valves in same, . . . . .	-	42	-	39	28	37	38	62	1	69	13	12	15	356
Air valves in same, . . . . .	5	102	3	35	4	19	34	29	-	9	-	-	-	240
Length laid or relaid during 1905 (feet), . . . . .	-	79	-	21	-	32	4	-	-	54	3	36	-	229
Gate valves in same, . . . . .	-	-	-	1	-	1	-	-	-	3	-	2	-	7
Air valves in same, . . . . .	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Length abandoned during 1905 (feet), . . . . .	-	16	-	9	-	3	33	-	-	2,310 <sup>1</sup>	3	-	-	2,374
Gate valves in same, . . . . .	-	-	-	-	-	-	1	-	-	2	-	-	-	3
Air valves in same, . . . . .	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Length owned and operated January 1, 1906 (feet), . . . . .	9,069	171,163	8,075	46,638	26,922	46,680	57,059	54,394	26	19,353	614	1,633	858	442,484 <sup>2</sup>
Gate valves in same, . . . . .	-	42	-	40	28	38	37	62	1	70	13	14	15	360
Air valves in same, . . . . .	5	102	3	35	4	19	34	29	-	9	-	-	-	240

<sup>1</sup> 2,300 feet 12-inch pipe sold to Malden in 1904.

<sup>2</sup> 83.80 miles.

TABLE NO. 35.— *Statement of Cast-iron Hydrant, Blow-off and Drain Pipes, owned and operated by Metropolitan Water and Sewerage Board.*

	DIAMETER OF PIPES IN INCHES.								Total.
	24	20	16	12	10	8	6	4	
Total length in use January 1, 1906 (feet), . . . . .	352	293	2,250	4,418	173	315	2,649	1,144	11,594
Total valves in use January 1, 1906, . . . . .	-	-	18	75	1	1	54	38	187



TABLE NO. 36. — Length of Water Pipes, Four Inches in Diameter and Larger, in the Several Cities and Towns supplied by the Metropolitan Water Works.

BY WHOM OWNED.	INCHES.														TOTAL.						
	60	48	42	40	36	30	28	24	20	18	16	14	12	10	8	7	6	5	4	Feet.	Miles.
Metropolitan Water Works.	9,069	171,163	8,075	-	46,638	26,922	-	46,680	57,059	-	54,394	26	19,353	614	1,633	-	858	-	-	442,484	83.80
Boston, . . .	-	33,494	16,813	23,104	43,264	90,052	244	78,090	94,913	-	199,455	-	1,179,046	142,483	592,233	-	1,317,626	-	86,631	3,897,448	738.15
Somerville, . . .	-	-	-	-	-	-	-	-	3,596	387	3,537	8,037	79,220	47,836	91,235	-	194,444	-	20,477	448,769	84.99
Malden, . . .	-	-	-	-	-	-	-	-	-	-	-	9,152	66,128	25,112	71,743	-	200,627	-	63,718	436,480	82.67
Chelsea, . . .	-	-	-	-	-	-	-	-	-	-	2,380	-	-	39,501	26,031	-	129,033	-	9,338	206,283	39.07
Everett, . . .	-	-	-	-	-	-	-	2,484	2,900	-	2,233	-	5,570	37,406	18,635	-	128,965	-	31,146	229,339	43.44
Quincy, . . .	-	-	-	-	-	-	-	-	2,679	-	23,232	-	23,548	32,166	88,376	994	218,799	948	97,232	487,974	92.42
Medford, . . .	-	-	-	-	-	-	-	-	673	-	6,775	9,784	24,658	33,220	67,371	-	91,612	-	41,869	275,962	52.26
Melrose, . . .	-	-	-	-	-	-	-	-	-	-	5,178	2,920	23,665	13,779	23,464	-	106,939	-	66,228	242,173	45.87
Revere, . . .	-	-	-	-	-	-	-	-	-	-	22,650	5,700	11,000	17,350	18,000	-	49,120	-	66,884	190,704	36.12
Watertown, . . .	-	-	-	-	-	-	-	-	-	-	400	12,127	5,959	4,169	19,261	-	110,060	-	13,239	165,215	31.29
Arlington, . . .	-	-	-	-	-	-	-	-	-	-	-	-	31,804	20,036	21,359	-	84,330	-	30,409	187,938	35.59
Milton, . . .	-	-	-	-	-	-	-	-	-	-	103	44	22,437	16,596	34,815	-	104,749	-	13,963	192,707	36.50
Winthrop, . . .	-	-	-	-	-	-	-	-	-	-	-	-	4,000	4,800	20,447	-	26,264	-	71,928	127,439	24.14
Stoneham, . . .	-	-	-	-	-	-	-	-	-	-	-	-	4,525	4,725	2,975	-	89,330	-	13,438	114,998	21.78
Belmont, . . .	-	-	-	-	-	-	-	-	-	-	-	-	2,161	12,302	13,696	-	75,659	-	283	104,101	19.72
Lexington, . . .	-	-	-	-	-	-	-	-	-	-	-	-	9,000	2,664	7,988	-	46,188	-	34,221	100,061	18.95
Nahant, . . .	-	-	-	-	-	-	-	-	-	-	-	-	150	11,550	4,850	-	32,740	-	35,100	84,390	15.98
Swampscott, . . .	-	-	-	-	-	-	-	-	-	-	-	-	12,072	13,634	13,217	-	48,131	-	9,110	96,164	18.21
Total feet, . . .	9,069	204,657	24,888	23,104	89,902	116,974	244	127,254	161,820	387	320,337	47,790	1,524,236	479,943	1,137,329	994	3,055,474	948	705,214	8,030,624	-
Total miles, . . .	1.72	38.76	4.71	4.38	17.03	22.15	.05	24.10	30.65	.07	60.67	9.05	238.69	90.90	215.40	.19	578.69	.18	133.56	-	1,520.95

TABLE NO. 37.— *Number of Service Pipes, Meters and Fire Hydrants in the Several Cities and Towns supplied by the Metropolitan Water Works.*

CITY OR TOWN.	Services.	Meters.	Fire Hydrants.
Boston, . . . . .	91,300	4,963	7,992
Somerville, . . . . .	11,279	2,092	1,001
Malden, . . . . .	6,829	5,332	405
Chelsea, . . . . .	6,423	634	306
Everett, . . . . .	4,999	92	506
Quincy, . . . . .	5,641	194	689
Medford, . . . . .	4,216	336	499
Melrose, . . . . .	3,354	110	289
Revere, . . . . .	2,700	108	137
Watertown, . . . . .	1,802	1,687	327
Arlington, . . . . .	1,894	419	363
Milton, . . . . .	1,160	1,160	293
Winthrop, . . . . .	1,908	30	120
Stoneham, . . . . .	1,275	22	110
Belmont, . . . . .	710	710	160
Lexington, . . . . .	685	15	102
Nahant, . . . . .	400	72	67
Swampscott, . . . . .	1,219	-	126
Total, . . . . .	147,794	17,976	13,492

TABLE No. 38. — Average Maximum and Minimum Monthly Heights, in Feet, above Boston City Base, to which Water rose, at Different Stations on the Metropolitan Water Works.

1905. MONTH.	LOW-SERVICE.										SOUTHERN HIGH-SERVICE.							
	BOSTON ENGINE HOUSE, BULFINCH STREET.		ALLSTON ENGINE HOUSE, HARVARD STREET.		MEDFORD, MYSTIC RESERVOIR.		MEDFORD WATER WORKS OFFICE, HIGH STREET.		SOMERVILLE CITY HALL ANNEX, WALNUT STREET.		MALDEN WATER WORKS SHOP, GREEN STREET.		CHELSEA WATER WORKS OFFICE, PARK STREET.		BOSTON METRO- POLITAN WATER WORKS OFFICE, 1 ASHBURTON PLACE.		WATERTOWN WATER WORKS OFFICE, MAIN STREET.	
	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Minimum.	Maximum.	Maximum.	Minimum.	Maximum.	Maximum.	Minimum.
January, .	124	116	184	174	166	163	167	164	170	165	162	159	153	146	246	236	262	259
February, .	122	116	186	179	165	162	162	159	166	161	159	157	147	140	246	235	262	259
March, .	135	123	191	184	168	165	167	165	170	166	163	160	157	149	249	238	264	260
April, .	147	124	186	176	167	163	167	164	167	162	163	160	162	152	249	238	264	261
May, .	146	124	190	180	169	165	168	166	170	165	165	162	165	155	249	236	262	255
June, .	141	122	187	177	167	164	167	165	169	165	164	162	163	154	246	235	261	255
July, .	138	121	189	178	170	165	167	164	170	164	164	161	164	153	245	234	261	254
August, .	147	128	192	173	168	164	166	164	169	164	164	160	163	153	245	236	261	254
September, .	148	131	182	173	168	165	166	164	169	163	162	159	162	153	245	236	262	255
October, .	153	131	185	174	168	165	167	165	168	163	164	162	162	154	246	236	262	258
November, .	152	133	183	174	168	165	167	165	167	162	164	162	162	154	248	236	263	259
December, .	145	131	184	174	168	165	167	165	167	161	164	161	161	152	247	237	264	260
Averages,	142	125	186	176	168	164	167	164	169	163	163	160	160	151	247	236	262	257



TABLE No. 38. — *Average Maximum and Minimum Monthly Heights, in Feet, above Boston City Base, etc. — Concluded.*

1905. MONTH.	SOUTHERN HIGH-SERVICE — Concluded.						NORTHERN HIGH-SERVICE.						NORTHERN EXTRA HIGH-SERVICE.										
	BELMONT TOWN HALL, PLEASANT STREET.			MILTON WATER WORKS OFFICE, ADAMS STREET.			QUINCY WATER WORKS SHOP.			SOMERVILLE PUMPING STA- TION, CEDAR STREET.			MALDEN CITY HALL.		REVERE WATER WORKS OFFICE, BROADWAY.		LYNN ENGINE HOUSE, UNION SQUARE.		LEXINGTON TOWN HALL, MASSA- CHUSETTS AVENUE.				
	Maximum.	Minimum.		Maximum.	Minimum.		Maximum.	Minimum.		Maximum.	Minimum.		Maximum.	Minimum.		Maximum.	Minimum.		Maximum.	Minimum.			
January, . . . . .	260	255		246	240		235	222		264	253		269	267		261	251		257	248		379	368
February, . . . . .	259	254		246	239		232	217		264	253		268	265		259	249		256	246		380	365
March, . . . . .	261	256		248	241		237	220		267	256		268	264		264	254		261	252		382	368
April, . . . . .	261	256		249	241		237	220		266	254		268	264		261	249		259	247		382	366
May, . . . . .	262	252		248	238		237	215		267	253		268	264		263	242		259	238		382	361
June, . . . . .	261	250		246	237		235	212		267	250		267	262		260	232		254	221		381	362
July, . . . . .	261	248		245	235		235	208		266	248		267	261		260	217		250	194		381	354
August, . . . . .	261	248		245	236		237	213		267	254		267	263		260	227		252	208		381	360
September, . . . . .	262	254		244	237		236	218		267	254		268	263		261	240		256	230		379	362
October, . . . . .	262	256		246	237		236	218		268	256		268	265		261	251		258	247		381	364
November, . . . . .	261	255		247	238		236	219		269	258		270	267		267	257		265	255		381	368
December, . . . . .	262	256		246	238		237	222		269	258		269	266		263	254		261	253		382	370
Averages, . . . . .	261	253		246	238		236	217		267	254		268	264		262	244		257	237		381	364

## APPENDIX No. 4.

## WATER WORKS STATISTICS FOR THE YEAR 1905.

The Metropolitan Water Works supply the Metropolitan Water District, which includes the following cities and towns: —

CITY OR TOWN.	Population, Census of 1905.	CITY OR TOWN.	Population, Census of 1905.
Boston, . . . . .	595,380	Watertown, . . . . .	11,258
Somerville, . . . . .	69,272	Arlington, . . . . .	9,668
Malden, . . . . .	38,037	Milton, . . . . .	7,054
Chelsea, . . . . .	37,289	Winthrop, . . . . .	7,034
Newton, <sup>1</sup> . . . . .	36,827	Stoneham, . . . . .	6,332
Everett, . . . . .	29,111	Lexington, . . . . .	4,530
Quincy, . . . . .	28,076	Belmont, . . . . .	4,360
Medford, . . . . .	19,686	Nahant, . . . . .	922
Hyde Park, <sup>1</sup> . . . . .	14,510	Total population of Metropolitan Water District.	946,300
Melrose, . . . . .	14,295	Swampscott, <sup>2</sup> . . . . .	5,141
Revere, . . . . .	12,659	Saugus, <sup>3</sup> . . . . .	200

<sup>1</sup> No water supplied to these places during the year from Metropolitan Water Works.

<sup>2</sup> Not in the Metropolitan Water District, but has been supplied with water from the Metropolitan Water Works.

<sup>3</sup> Only a small portion of Saugus is supplied with water.

*Sources of Supply.*

SOURCE.	Area of Watershed (Square Miles).	Remarks.
Lake Cochituate, . . . . .	18.87	Works built by city of Boston in 1848.
Sudbury River, . . . . .	75.20	Works built by city of Boston in 1872-78.
Nashua River (South Branch), . . . .	118.31	Works begun in 1895; not finished.

*Mode of Supply.*

25 per cent. from gravity.

75 per cent. from pumping.

Pumping.

Chestnut Hill High-service Station : —

Builders of pumping machinery, Holly Manufacturing Company, Quintard Iron Works and E. P. Allis Company.

Description of coal used : — Bituminous : Quemahoning, Priscilla and Georges Creek Cumberland ; anthracite : buckwheat and screenings. Price per gross ton in bins : bituminous \$4.12 to \$5.28, buckwheat \$3.02 to \$3.58, screenings \$2.52. Average price per gross ton \$3.93. Per cent. ashes, 11.5.

Chestnut Hill Low-service Station : —

Builders of pumping machinery, Holly Manufacturing Company.

Description of coal used : — Bituminous : Quemahoning and Georges Creek Cumberland ; anthracite : buckwheat. Price per gross ton in bins : bituminous \$3.98 to \$4.37, buckwheat \$2.78 to \$3.26. Average price per gross ton \$3.78. Per cent. ashes, 12.3.

Spot Pond Station : —

Builders of pumping machinery, Geo. F. Blake Manufacturing Company and Holly Manufacturing Company.

Description of coal used : — Bituminous : Quemahoning ; anthracite : buckwheat and screenings. Price per gross ton in bins : bituminous \$4.38, buckwheat \$3.75, screenings \$2.24. Average price per gross ton \$3.61. Per cent. ashes, 12.1.

	CHESTNUT HILL HIGH-SERVICE STATION.		
	Engines Nos. 1 and 2.	Engine No. 3.	Engine No. 4.
Daily pumping capacity (gallons), . . . . .	16,000,000	20,000,000	30,000,000
Coal consumed for year (pounds), . . . . .	1,985,452	424,881	8,505,184
Cost of pumping, figured on pumping station expenses, . .	\$9,311.51	\$2,090.02	\$26,766.67
Total pumpage for year, corrected for slip (million gallons), .	1,381.48	481.82	10,564.86
Average dynamic head (feet), . . . . .	120.87	128.01	130.39
Gallons pumped per pound of coal, . . . . .	695.80	1,134.01	1,242.17
Duty on basis of plunger displacement, . . . . .	76,310,000	130,650,000	139,070,000
Cost per million gallons raised to reservoir, . . . . .	\$6.740	\$4.338	\$2.534
Cost per million gallons raised one foot, . . . . .	0.056	0.034	0.019



	CHESTNUT HILL LOW-SERVICE STATION.	SPOT POND STATION.	
	Engines Nos. 5, 6 and 7.	Engine No. 8.	Engine No. 9.
Daily pumping capacity (gallons), . . . . .	105,000,000	10,000,000	20,000,000
Coal consumed for year (pounds), . . . . .	8,215,258	190,381	2,374,510
Cost of pumping, figured on pumping station expenses,	\$31,850.16	\$1,217.28	\$10,656.01
Total pumpage for year, corrected for slip (million gallons).	20,104.86	189.55	2,818.20
Average dynamic head (feet), . . . . .	50.81	119.05	129.52
Gallons pumped per pound of coal, . . . . .	2,447.26	995.64	1,186.86
Duty on basis of plunger displacement, . . . .	106,730,000	100,770,000	132,060,000
Cost per million gallons raised to reservoir, . . . .	\$1.584	\$6.422	\$3.781
Cost per million gallons raised one foot, . . . .	0.031	0.054	0.029

Consumption.

Estimated total population of the nineteen cities and towns supplied wholly or partially during the year 1905, . . . . .	902,090
Total consumption, gallons, . . . . .	43,215,210,000
Average daily consumption, gallons, . . . . .	118,398,000
Gallons per day to each inhabitant, . . . . .	131.2

Distribution.

	Owned and operated by Metropolitan Water and Sewerage Board.	Total in District supplied by Metropolitan Water Works.
Kinds of pipe used, . . . . .	- <sup>1</sup>	- <sup>2</sup>
Sizes, . . . . .	60 to 6 inch.	60 to 4 inch.
Extensions less length abandoned, miles, . . . . .	— .41	13.14
Length in use, miles, . . . . .	83.80	1,520.95
Stop gates added, . . . . .	4	-
Stop gates now in use, . . . . .	360	-
Service pipes added, . . . . .	-	1,933
Service pipes now in use, . . . . .	-	147,794
Meters added, . . . . .	-	2,730
Meters now in use, . . . . .	-	17,976
Fire hydrants added, . . . . .	-	203
Fire hydrants now in use, . . . . .	-	13,492

<sup>1</sup> Cast-iron and cement-lined wrought iron.    <sup>2</sup> Cast-iron, cement-lined wrought iron and kalamine.

## APPENDIX No. 5.

## SPECIAL REGULATIONS OF THE METROPOLITAN WATER AND SEWERAGE BOARD RELATING TO BOATING AND FISHING IN THE WATERS OF LAKE COCHITUATE.

Under and in pursuance of Rule 14 of the rules made by the State Board of Health on January 1, 1899, for the sanitary protection of waters used by the Metropolitan Water Board for the water supply of cities and towns in the Metropolitan Water District, and also under and in pursuance of the general powers and authority given to the Metropolitan Water and Sewerage Board, the following special regulations relative to boating and fishing in the waters of Lake Cochituate were made on August 9, 1905, and December 6, 1905: —

I. Special Regulation No. 1, adopted by the Metropolitan Water Board on June 30, 1899, under and in pursuance of Rule 14 of the rules made by the State Board of Health on June 1, 1899, for the sanitary protection of waters used by the Metropolitan Water Board, and under and in pursuance of the general powers and authority given to the Metropolitan Water Board, which special regulation was readopted by the Metropolitan Water and Sewerage Board on May 10, 1901, is hereby rescinded, so far as it applies to fishing and boating in the waters of Lake Cochituate, after December 31, 1905, and the permission therein given shall, beginning with January 1, 1906, and until further order, be to fish and boat only in or upon the waters of Farm Pond and Whitehall Reservoir, subject to the limitations and conditions in said regulations contained.

II. No permission is given after December 31, 1905, to fish or boat in the waters of that portion of Lake Cochituate, which is situated northerly of the county road known as Lake Avenue.

III. Permission is given during the season beginning with April 1 and ending with September 20, until further order, to fish from the highway and in boats which have been duly registered and numbered in accordance with the requirements of the Metropolitan Water and Sewerage Board, in that portion of the waters of Lake Cochituate which is situated southerly of the county road known as Lake Avenue; and permission is also given to enter from the highway and fish through the ice in said portion of the waters of Lake Cochituate, subject in both cases to the following limitations and conditions: —

(a) No fish, food or other matter tending to pollute the water shall be thrown into the water or left upon the shores.

(b) No tin cans or bait boxes shall be thrown into the water or left upon the shores.

(c) No person shall build any fire upon the shores or other land belonging to the Commonwealth or upon the ice of the lake.

(d) Care shall be taken not to disturb the gravel or stone protection around the shores.

(e) In case fishing is carried on through the ice, no person shall throw or leave upon the ice any fish, bait, food or other matter tending to pollute the water.

(f) No permission is given to fish from the shores at places other than the highway.

IV. Permission is given, in the year 1906 and until further order, during the season beginning with April 1 and ending with September 20, to boat in and upon that portion of the waters of Lake Cochituate which is situated southerly from the county road in Natick known as Lake Avenue, in boats which have been duly registered and numbered in accordance with the requirements of the Metropolitan Water and Sewerage Board; but such permission shall apply only when one of the occupants of the boat is duly licensed by the said Board to use and operate a boat upon said lake. Such permission is subject to the limitations and conditions set forth in the rules for registration and licensing adopted by said Board.



APPENDIX No. 6.

CONTRACTS MADE AND PENDING DURING THE YEAR 1905 — SEWERAGE WORKS.  
*Contracts relating to the South Metropolitan System.*

1. Num- ber of Con- tract.	2.  WORK.	3.  Num- ber of Bids.	AMOUNT OF BID.		6.  Contractor.
			4. Next to Low- est.	5. Lowest.	
16	Section 77, High-level Sewer, Roxbury, pump- ing plant for Ward Street pumping station.	3	\$207,000 00	\$204,000 00	Allis-Chalmers Co., Mil- waukee, Wis.

7.  Date of Contract.	8.  Date of Completion of Work.	9.  Prices of Principal Items of Contracts made in 1905.	10.  Value of Work done Decem- ber 31, 1905.
Jan. 17, '02,	-	-	\$153,000 00

## APPENDIX No. 7.

## COMMONWEALTH OF MASSACHUSETTS.

## SUPREME JUDICIAL COURT.

SUFFOLK, SS.

IN EQUITY.

HENRY H. SPRAGUE, HENRY P. WALCOTT AND JAMES A. BAILEY, JR.,  
METROPOLITAN WATER AND SEWERAGE BOARD, *Petitioners*.

[*In re* THE SOUTH METROPOLITAN SEWERAGE SYSTEM, *St. 1899, c. 424.*]

## REPORT AND AWARD.

The Commissioners appointed in the above case, after due notice, met the attorneys, solicitors and representatives of the several cities and towns named in the petition, and fully heard such evidence and arguments as were offered and made in behalf of each city and town, and now, after careful consideration of the same, award, determine and report to the Court as follows: —

The petition is a petition for the appointment of commissioners under the provisions of section 16 of chapter 424 of the Acts of the year 1899, being entitled “An Act to provide for the construction of a high-level gravity sewer for the relief of the Charles and Neponset River valleys,” to determine the proportion in which each of the cities and towns comprising said system shall annually pay money into the treasury of the Commonwealth for the term of five years, to meet the interest and sinking fund requirements for each of said years as estimated by the Treasurer, and to meet the cost of maintenance and operation of said system for each of said years as estimated by the said Board and certified to said Treasurer, and any deficiency in the amount previously paid in, as found by said Treasurer.

There have been four Boards of Commissioners previously appointed by this Court to determine the proportion in which the several cities and towns should bear the costs of construction, maintenance and operation of the

Metropolitan sewers, under statutes substantially similar to the act in question.

The first Board was appointed in May, 1891, and made its report in November, 1891, in which the Commissioners say: —

We have come to the conclusion that there is, upon the whole, no method more just and equitable than to apportion the payments on account of the interest and sinking fund requirements of the loan which represents the first cost of the systems with primary reference to the total taxable valuations of the several cities and towns; and the payments on account of the cost of maintenance and operation with primary reference to their respective populations.

The second Board was appointed in October, 1895, and made its report in October, 1896, adopting the same basis for the apportionment, and say: —

We have been unable to find, upon the whole, any better measure of the ability and duty to contribute to the cost of public works of this character than the taxable valuations of the several cities and towns which compose the districts for whose common welfare these systems were created, or any better measures of the use enjoyed and the benefits received by the several municipalities than the number of persons who dwell within their respective limits.

The third Board was appointed in March, 1900, being the first apportionment made for the South Metropolitan System, and in the report the Commissioners say: —

There does not seem, on the whole, to be any fairer method of assessing the cost of construction of great public undertakings of this kind than that of assessing such cost on the various cities and towns according to their taxable valuation. On the other hand, it is undoubtedly true that after construction the use made of the sewerage system by each city and town depends upon the number of inhabitants in such city or town; and, as the cost of maintenance and operation is directly proportional to the amount of sewage discharged, *i.e.*, the use made of the system, it would seem that the basis of population would be a just and equitable method of assessing such expense.

The fourth Board was appointed in May, 1901, for the North Metropolitan System, and made its report, in which the Commissioners say: —

We have been urged by the representatives of several municipalities to adopt a different method of distribution than that followed by the Commissioners who have previously made the apportionment; but the weight of opinion expressed at the hearings was very clearly in favor of continuing the methods hitherto adopted,



and in our judgment, particularly in view of precedent, the weight of argument demands such course. We are satisfied that the plan adopted accomplishes substantial justice in the distribution of the burden in accordance with the benefits received.

All of these reports were accepted by the Court, and the basis of apportionment approved.

While we do not feel bound absolutely by the rule or basis of apportionment thus adopted, and should feel at liberty to correct any errors which the practical working of the rule might seem to us to require, or to deal with any new condition of things arising since the other apportionments were made, still, we cannot but feel that a rule thus adopted by four different Boards after full hearing and trial, and approved and sanctioned by this Court and acted on by all and acquiesced in by at least a very large majority of the municipalities affected for so many years, ought not to be departed from except for the strongest reasons.

In the apportionment of the payments of the money needed to meet the requirements of the statute in question among the municipalities named in the act, it is manifest that any rule or basis adopted must be general in its application, to avoid any question of favoritism to any particular locality arising under it; and must be made, too, so far as possible, with due regard to the rules and the general system or methods of taxation adopted and sanctioned by the laws of the Commonwealth.

At the hearings before us the towns of Brookline and Milton both objected to an apportionment based on the assessed valuation of the towns for the construction of the sewer, but made no objection to the basis of population for the cost of its maintenance and operation. Both of these towns are wealthy, residential towns, and the assessed valuation of each is large in proportion to its area and population, — very much larger than that of any other city or town in the District; and it was urged upon us with a good deal of zeal and earnestness that, because of this large valuation, any apportionment made on the basis of it would work injustice and be inequitable and unjust to these towns.

We have examined the claims thus made, and we have examined also much of the evidence, arguments and suggestions made to the Commissioners who made the awards above referred to; but we are unable to find that the claims made in behalf of these towns are well founded, or that either town has any just cause of complaint. On the contrary, we are clearly of the opinion that the basis of assessed valuation for the cost of construction and population as a basis for the cost of maintenance and operation, while open, of course, to some criticisms, approximates more nearly to a just and equitable apportionment than any other basis or method

suggested or which has occurred to us. The rule is simple, plain and practicable, easily understood and easily applied, and accords most nearly with our established principles of taxation; and we accordingly adopt this rule in making the apportionment.

The valuations set forth in the tables are published in chapter 178 of the Acts of 1904, and involve real and personal estate, bank stock and shipping, and are the valuations used in assessing the State tax. For all of the contributing municipalities except Boston and Dedham the whole valuation of the city or town has been used. In Boston the South Metropolitan District embraces all of the Brighton District and parts of the Back Bay, Roxbury, West Roxbury and Dorchester districts. In the town of Dedham a small area of the southerly corner adjacent to the Neponset River is excluded. The valuation of the parts of Boston included in the district and of the parts of Dedham not excluded were compiled by or under the direction of the Chief Engineer of the Metropolitan Water and Sewerage Board, and were assumed by all parties to be correct.

In the table of population the census determinations of 1900 are taken for all the cities and towns except Boston, and for those of Boston included in the District they are compiled from official sources under the direction of the Chief Engineer, and are correct.

The counsel for the town of Watertown asked us to exclude one hundred and five acres in the northwesterly and northerly part of the town, with a valuation of \$219,750 and a population of 333, from the valuation and population in making the apportionment, on the ground that this area cannot be drained into the South Metropolitan System without great expense, and on the further ground that the town has applied to the Legislature for the admission of that part of the town into the North System; but, as the territory in question still lies in and forms a part of the South District, we have not excluded it.

No other city or town made any objection or suggested any change in the method of apportionment, although each city and town was represented before us by counsel at nearly all of the hearings held.

1. *Interest and Sinking Fund Requirements.*—We therefore determine and award that the several cities and towns in the South Metropolitan District shall annually pay money into the treasury of the Commonwealth for the term of five years, 1905 to 1909, both inclusive, to meet the interest and sinking fund requirements for each of said years, as estimated by said Treasurer, of the Metropolitan Sewerage Loan authorized and issued for the construction of said South Metropolitan System, including the interest and sinking fund requirements of the former Charles River valley and Neponset valley systems, so called, and any deficiency in the amount

previously paid in, as found by said Treasurer, in the proportions in the right-hand column of the following table : —

Table showing the Proportions in which the Several Cities and Towns in the South Metropolitan System shall pay Money to meet the Interest and Sinking Fund Requirements under St. 1899, c. 424.

CITY OR TOWN.	Valuation.	Proportion (Per Cent.).
Waltham, . . . . .	\$23,297,415	4.95
Watertown, . . . . .	12,921,271	2.74
Newton, . . . . .	71,356,289	15.16
Boston, { Brighton District, . . . . .	\$34,744,400	
{ Back Bay District, . . . . .	37,160,800	
{ Roxbury District, . . . . .	38,470,750	
{ West Roxbury District, . . . . .	35,322,200	
{ Dorchester District, . . . . .	42,529,800	
Total for Boston, . . . . .	188,227,950	39.98
Brookline, . . . . .	102,306,308	21.73
Dedham, . . . . .	10,965,988	2.33
Hyde Park, . . . . .	12,415,331	2.64
Milton, . . . . .	25,435,822	5.40
Quincy, . . . . .	23,894,528	5.07
Total, . . . . .	\$470,820,902	100.00

2. *Cost of Maintenance and Operation.* — We determine and award that the several cities and towns in the South Metropolitan System shall annually pay money into the treasury of the Commonwealth for the term of five years, 1905 to 1909, both inclusive, to meet the cost of maintenance and operation of said systems for each of said years, as estimated by the Metropolitan Water and Sewerage Board and certified to said Treasurer, and any deficiency in the amount previously paid in, as found by said Treasurer, in the proportion shown in the following table : —



Table showing the Proportions in which the Cities and Towns in the South Metropolitan System shall annually pay Money to meet the Cost of Maintenance and Operation of Said System under St. 1899, c. 424.

CITY OR TOWN.	Population. 1900.	Proportion (Per Cent.).
Waltham, . . . . .	23,481	9.11
Watertown, . . . . .	9,706	3.76
Newton, . . . . .	33,587	13.03
Boston, { Brighton District, . . . . .	19,279	
{ Back Bay District, . . . . .	17,534	
{ Roxbury District, . . . . .	27,760	
{ West Roxbury District, . . . . .	23,603	
{ Dorchester District, . . . . .	31,745	
Total for Boston, . . . . .	119,921	46.52
Brookline, . . . . .	19,935	7.73
Dedham, . . . . .	7,457	2.89
Hyde Park, . . . . .	13,244	5.14
Milton, . . . . .	6,578	2.55
Quincy, . . . . .	23,899	9.27
Total, . . . . .	257,808	100.00

PATRICK H. COONEY,  
OSCAR A. MARDEN,  
NATHANIEL N. JONES,  
*Apportionment Commissioners.*

Boston, June 9, 1905.

APPENDIX No. 8.

LEGISLATION OF THE YEAR 1905 AFFECTING THE  
METROPOLITAN WATER AND SEWERAGE BOARD.

ACTS OF 1905.

[CHAPTER 211.]

AN ACT TO ESTABLISH A NEW FISCAL YEAR FOR THE COMMONWEALTH.

*Be it enacted, etc., as follows :*

SECTION 1. The fiscal year of all offices, departments, boards, commissions, hospitals, asylums, charitable, penal and reformatory institutions of the Commonwealth shall begin with the first day of December and end with the following thirtieth day of November, and all books and accounts therein shall be kept by fiscal years as herein established, and the annual reports of all officers, trustees, boards and commissions, except the report of the insurance commissioner and except those reports otherwise provided for in this act, shall be made to the governor and council, or to the general court, as now required by law, except that they shall be made on or before the third Wednesday in January, anything in any general or special statute now existing to the contrary notwithstanding. Such reports shall be deposited with the secretary of the Commonwealth, who shall transmit them to the governor and council or to the general court. The financial statements now required by law to be included therein shall be made for the fiscal year as herein established. The annual meetings of trustees of state institutions and of state boards, at which financial statements are required by law to be presented, shall be held in the month of December in each year.

The fiscal year of the Commonwealth to begin December 1, etc.

. . . . .  
SECTION 14. This act shall take effect on the thirty-first day of December in the year nineteen hundred and five.  
[Approved March 23, 1905.]

## [CHAPTER 214.]

## AN ACT MAKING AN APPROPRIATION FOR OPERATING THE SOUTH METROPOLITAN SYSTEM OF SEWAGE DISPOSAL.

*Be it enacted, etc., as follows :*

South Metro-  
politan system  
of sewage  
disposal.

SECTION 1. A sum not exceeding one hundred and forty-four thousand nine hundred and twenty dollars is hereby appropriated, to be paid out of the South Metropolitan System Maintenance Fund, for the cost of maintenance and operation of the south metropolitan system of sewage disposal, comprising a part of Boston, the cities of Newton, Quincy and Waltham, and the towns of Brookline, Watertown, Dedham, Hyde Park and Milton, during the year ending on the thirty-first day of December, nineteen hundred and five.

SECTION 2. This act shall take effect upon its passage  
[*Approved March 24, 1905.*]

## [CHAPTER 215.]

## AN ACT MAKING AN APPROPRIATION FOR OPERATING THE NORTH METROPOLITAN SYSTEM OF SEWAGE DISPOSAL.

*Be it enacted, etc., as follows :*

North Metro-  
politan system  
of sewage  
disposal.

SECTION 1. A sum not exceeding one hundred and twenty-seven thousand dollars is hereby appropriated, to be paid out of the North Metropolitan System Maintenance Fund for the maintenance and operation of the system of sewage disposal for the cities and towns included in what is known as the north metropolitan system, during the year ending on the thirty-first day of December, nineteen hundred and five.

SECTION 2. This act shall take effect upon its passage.  
[*Approved March 24, 1905.*]

## [CHAPTER 457.]

## AN ACT RELATIVE TO ASSESSMENTS UPON CITIES AND TOWNS IN THE METROPOLITAN WATER, SEWERAGE AND PARK DISTRICTS.

*Be it enacted, etc., as follows :*

Assessments  
upon cities  
and towns in  
the Metropoli-  
tan water,  
sewerage and  
park districts.

SECTION 1. In case any apportionment for assessment upon the cities and towns of either the metropolitan water, sewerage or park districts shall not have been finally determined by July first of any year, the last apportionment thereof shall remain in



force for the purpose of assessment during such current year. Any difference between such apportionment when finally made by the commission, for such year, and the preëxisting apportionment above referred to, shall be adjusted with such city or town by the treasurer and receiver general in the assessment of the succeeding year by a deduction therefrom or an addition thereto, as may be required to give effect to the said apportionment when made as aforesaid.

SECTION 2. This act shall take effect upon its passage.  
[Approved May 25, 1905.

[CHAPTER 466.]

AN ACT TO AUTHORIZE THE BOSTON ELEVATED RAILWAY COMPANY  
TO CONSTRUCT A SUBWAY OR SUBWAYS IN THE CITY OF CAM-  
BRIDGE.

*Be it enacted, etc., as follows :*

. . . . .

SECTION 10. Upon the written request of the company, the city shall order the temporary or permanent removal or relocation of any surface tracks, conduits, pipes, wires, poles, or other property of the Commonwealth, or of any person or corporation except the city or the company, which the company deems to interfere with the construction or operation of the subway or subways, and the city shall grant new locations for any such structures previously having locations. Such order, to the extent specified therein, shall be deemed a revocation of the right or license to maintain such surface tracks, conduits, wires, pipes, poles or other property, and the owner of any such structures in public ways or lands shall comply with such order without expense to the company. If such owner shall fail to comply with such order within a reasonable time to be fixed therein, the company may remove such surface tracks, conduits, pipes, wires, poles or other property, and may relocate and reconstruct the same, and the cost of such removal, relocation and reconstruction shall be repaid to the company by the owner. No such discontinuance, removal or relocation shall entitle the owner of the property thus affected to any damages on account thereof. The removal and relocation of any property of the Commonwealth shall be subject to the approval of the board having charge thereof, and at the expense of the company. Any gas or electric lighting company may shut off the gas or

Pipes, etc.,  
may be  
removed.

current from any pipes or wires affected by any action done hereunder, when and so far as may be necessary to avoid the escape or explosion of gas, or to avoid other public danger. Temporary locations shall be granted on request of the company, for any surface tracks owned or operated by it; and, as soon as the state of the work permits the same may be restored to the original locations as nearly as may be.

. . . . .  
[Approved May 26, 1905.

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[CHAPTER 55.]

RESOLVE IN FAVOR OF MICHAEL MORGAN.

Payment  
to Michael  
Morgan.

*Resolved*, That there be allowed and paid out of the Metropolitan Water Maintenance Fund the sum of six hundred and fifty dollars to Michael Morgan of Natick, an employee of the metropolitan water and sewerage board, on account of the death of his daughter, Mary Morgan, ten years of age, who was drowned on the twenty-seventh day of July in the year nineteen hundred and three, by falling into the Sudbury aqueduct of the metropolitan water works in the town of Natick through a trap door which was negligently left open by employees of the Commonwealth. [Approved April 21, 1905.

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